THE

MECHANICAL

MINERS' GUIDE

ISSUED BY

A. S. HALLIDIE

WIRE AND WIRE ROPE WORKS

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NOTE.

The Scales, Tables and Rules contained in this pamphlet have been carefully compiled and condensed from the best authorities, and I have endeavored throughout to make use of only such as the requirements of the mechanic and miner call for.

The compiler for many years resided and worked in the mining region, and often felt the want of a small pamphlet containing the weight and strength of different materials; rules for calculating the velocity and power of water, etc., etc., and the strength and weight of ropes and chains and such general information.

It is offered with a full description and explanation of the use of Wire Rope, Wire Rope transportations, transmission of power by Wire Rope, Wire Rope Street Railroads, etc., to those interested, trusting to meet their approbation.

A. S. HALLIDIE.

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Iron & Steel Wire Rope Works & Wire Mills

SAN FRANCISCO, CAL., 1879.

I am prepared to furnish the Mining, Manufacturing, Shipping and Ferry Interests on the Pacific Coast, with Iron and Steel Wire Rope of all kinds, in any length, size and quantity desired, from my manufactory in San Francisco, on favorable terms.

A. S. HALLIDIE.

The adaption of Iron Wire to the manufacture of Ropes, is due to Mr. Andrew Smith, a civil engineer by profession, and a native of Annan, in the south of Scotland. His first experiments were made in 1828. As a substitute for raw hide ropes, he employed as counterbalance ropes for shutters and elevators; and the partial success he met with was encouraged by the great advance in the price of Russian hemp. His first patent was dated January 12th, 1835; his second patent was dated March 26th, 1836. A third patent was granted him on December 21st, 1836, and a fourth patent was granted him March 20th, 1839; and at subsequent dates other patents were issued him for improvements in Wire Ropes and Wire Rope machinery. Since then Wire Rope has become an important industry, and has added much to the wealth of the country in helping to develop the iron interests.

Wire Rope is now generally employed for Mining, Ferry, Shipping and general purposes; and forty years' experience has proved that it possesses many great advantages over Hempen Ropes—being lighter, stronger, more durable and cheaper than Hemp or Manila, and is not affected by atmospheric changes.

The many purposes to which Wire Rope has been applied where Hemp Rope would soon have been destroyed, and Chain found too heavy, soon induced its general adoption throughout the mining regions of the civilized world; wherever shafts and incline plains are sunk to great depths, and the universal preference given to it over other ropes and chain, is a sufficient guarantee of its superiority. In California the consumption of rope for mining purposes is very great.

Until the erection of my Works, in 1857, Wire Rope was not in the market, although the requirements of the mining and shipping interests had long demanded it. This demand I have since been able to supply, and have during the past year, remodeled my works, with machinery of the most approved pattern, capable of turning out all kinds of Flat and Round Wire Rope which I guarantee to be equal to any made. The Wire Rope Works being under my immediate superintendence I am enabled to manufacture an article suitable for this market in every respect.

Round Wire Ropes are made from charcoal iron, bessemer steel or refined crucible steel, galvanized or not, and of each of these two kinds of Wire Rope are made, Coarse Rope having 42 wires and Flexible Rope having 114 wires. The latter being used for hoisting, etc., when the sheaves or drums are of small diameter.

In addition to the Round Ropes, Flat Iron or Steel Wire Ropes are made from 2 inches to 10 inches wide, and from ¼ to 1¼ inches thick.

It is almost impossible to specify the precise uses to which Wire Rope is adapted in preference to hempen ropes or chain; but for the following purposes it has been a long time in use, and in every respect is much preferred:

For Hoisting from Deep Shafts and Incline Planes.
For Guy Ropes for Derricks.
For Pump Ropes for driving River Machinery.
For Suspension Cables for Water Conduits or Aqueducts.
For Signal Cord.
For Ferry Ropes
For Ships' Standing Rigging.
For Tiller Ropes for Steamers.
For Guy Ropes for Smoke Stacks.
For Sash Cord for Window Sashes, Hanging Pictures, etc.
For Power Ropes, for conveying power to any distance.
For Wire Tramways.
For Endless Wire Ropeway, for the transportation of material over mountainous and difficult roads, etc.
For Steam Cultivation and Land Tillage.
For Street Railroads.
For Ships' and Tugs' Hawsers.
For Thoroughbraces, etc., etc.
For Store and Hotel Elevators.
Lightning Conductors for the protection of Dwellings, Ships' Masts, etc.

General Remarks on Wire Rope.

The numerous purposes to which rope is applied, its great cost being a large item in a mining company's expenses, necessitates the use of economy in its application ; therefore, when it is satisfactorily proved, that by the application of Wire instead of Hemp Ropes, a saving can be effected, it should be a guarantee of its general adoption.

When the machinery is properly arranged, and drums and pulleys properly proportioned, the durability of Wire Rope over the best quality of Hempen Ropes is as 3 to 1. But Wire Rope can be destroyed like other rope, if badly used; and as we do not claim for Wire Rope more than it deserves, the surest test is a fair trial ; but we do claim for it the following advantages over other ropes, under a fair and legitmate trial :

1st—It is less than two-thirds the weight of dry Hemp Rope.

2d—It is but one-fourth the weight of a wet Hemp Rope.

3d—It is less than one-half the size for same strength.

4th—It does not stretch and shrink (being unaffected by the atmosphere), nor does it absorb moisture.

5th—It is three to five times as durable.

6th—The excessive heat of the Summer sun does not rot it, nor does the moisture of Winter cause it to swell.

7th—It can be spliced as easily, wet or dry—frozen or otherwise —and more snugly and neatly than Hemp Rope.

8th—And lastly—We do not have to send to Manila or Russia, or any other foreign country, for the raw material, but obtain it from the iron-fields of our own country, thus being essentially a home-manufactured article.

Wire Rope is usually made of six strands, the core or heart around which it is formed being either hemp or wire; the former being preferred for hoisting ropes, or where the rope works around a sheave or draw. The strands are formed of six wires around a centre wire, thus giving in all 42 wires to the rope. This is the best form for a

rope which has to work over sheaves and drums of large diameters, or in cases where the ropes are used as guys or stays. When sheaves and drums of comparative small diameter are employed, then the strands are composed of much smaller wires, and usually nineteen wires form each strand, giving 114 wires to the rope, and making a very soft and flexible rope. The rigidity or flexibility of a rope is also modified as the wire is either soft or hard. For a rope of great tensile strength, hard drawn wire is required, but if it is necessary to have a rope of extreme softness and flexibility, annealed wire can be used ; but it must be born in mind that wire loses 40 per cent. of its tensile strength by annealing. Refined Crucible Steel Wire largely combines both qualities of great tensile strength, flexibility and toughness.

Explanation of the Signs used in this Work

Addition or plus, .	$+$	Division, . .	$\div$	Cube Root, .	$\sqrt[3]{}$
Subtraction or minus	—	Equal to, . .	$=$	Square, . . .	^{2}
Multiplication, .	$\times$	Square Root, .	$\sqrt{}$	Cube, ...	^{3}

On the Power of Blocks and Tackles.

RULE FOR ASCERTAINING THE POWER TO BE EXERTED IN RAISING WEIGHTS BY PULLEYS.

When only one Rope or Cord is used.

RULE—Divide the weight to be raised by the number of the parts of the rope engaged in supporting the lower or movable block.

Ex. 1. What power is required to raise 1200 lbs. when the lower block contains six sheaves, and the end of the rope is fastened to the upper block?

1200 lbs. $\div$ 12 $=$ 100 lbs., the power to be exerted.

Ex. 2. Suppose the end of the rope is fastened to the lower blocks, what power is required?

$1200 \div 13 = 92\frac{4}{13}$ lbs., the power to be exerted.

TO ASCERTAIN WHAT WEIGHT CAN BE RAISED BY CERTAIN POWER EXERTED.

RULE.—Multiply the number of the parts of the rope by the power exerted.

Example. Suppose six parts of rope to be used and fifty pounds power exerted—the weight that can be raised will be 300 lbs.

Note—The Weston differential or Doyle Chain Pulley consists of a double and single block, the upper block consisting of two chain sheaves, of different diameters, fixed to each other—the lower block being a single chain sheave. The power gained being in proportion to the difference in the diameters of the two upper sheaves—the smaller the difference the greater the power, and *vice versa.* The chain fall is endless and does not run back by the load being hoisted. Heavy derricks and cranes have recently been fitted up with wire rope tackle, two, three or four fold, iron blocks with sheaves 12 or 14 inches diameter, with a steel rope 1¼ inch circumference for a fall, works very much smoother than chain, and does not rot out like a Manila fall rope.

Galvanized Iron Wire Rope for Ships' Standing Rigging

Possesses many advantages over Hemp, requiring no stripping or refitting, as Hemp Rope must have every few years ; and being once set up, it obviates the attention and trouble caused by the stretching and shrinking of Hemp, and by its extreme lightness, being but two-thirds the weight of Hemp, increases the ship's capacity for cargo. And the advantage derived from the smaller surface opposed to the wind, (Wire Rope being one-half the size of Hemp) especially in beating to windward, needs no comment—while for the jib and flying jib stays, its smallness and smoothness permit the hanks to travel on it much more freely.

The following are some of the Advantages of Wire Rope:

1. Wire Rope is not affected by the atmospheric changes, consequently does not stretch or shrink in dry or wet weather, avoiding the necessity of repeated setting up as in Hemp.

2. Wire Rope is 40 per cent. less weight than Hemp, saving so much top hamper.

3. Wire Rope is very much smaller for equal strength, and having but four-tenths the surface of Hemp Rope exposed to the wind, enables the ship to run closer to the wind.

4. Wire Rope is spliced equally well in all kinds of weather, and much more neatly than Hemp.

5. The jib runs down Wire Rope freer, seldom requiring the down haul.

6. Wire Rope presents a neat and trim appearance, looks ship-shape; and one suit of wire-rigging in the absence of accident, will last the ship's life.

7. Lastly, and to ship owners very important! Wire Rope COSTS VERY MUCH LESS than Hemp or Chain.

EXTRACT FROM THE REPORT OF THE SECRETARY OF THE NAVY, 1867.

"During the year twenty-three vessels have been wholly, and several others partially wire rigged. Tests of the comparative strength of Wire and Hemp Rope, and reports of commanders of wire rigged vessels have been so satisfactory, that the Bureau recommend the erection of a building, and the purchase of necessary machinery for the manufacture of wire rigging," (at Charlestown Navy Yard.)

EXTRACT FROM SAN FRANCISCO *Times*, AUGUST, 1867, IN REFERENCE TO THE BURNING OF THE SHIP "*Blackwall*," IN THIS HARBOR.

"The forehold, where the fire originated, was burned nearly down to the shell—the forecastle was completely destroyed, the foremast so badly burned that it will have to be taken out, and the houses on deck were also rendered useless. *It was a fortunate thing that the ship's rigging was all wire; had she been rigged with hemp, the shrouds would, of course, have caught fire*, and the masts and yards would in all probability have been burned, and the difficulty of saving her would have been doubled."

Wire Rope possesses so many advantages for the standing rigging of ships that it is rapidly displacing every other kind of rigging.

Tensile Strength of Materials.

Weight or force necessary to tear asunder 1 in. square in lbs.

Metals.

Copper............lbs.	32,500	Lead, cast.........lbs.	1,800
Copper Wire ...... "	61,200	" milled....... "	3,320
Gold, cast......... "	20,000	Platinum Wire..... "	53,000
Iron cast, lbs., 18,000 to	30,000	Silver, cast........ "	40,000
" medium bar...lbs.	50,000	Steel soft.......... "	120,000
Iron Wire......... "	100,000	" razor......... "	150,000
" " annealed.. "	60,000	Ref'd Cr'cibl Steel Wire	175,000

Woods.

Ash............	lbs.	16,000	Mahogany...........	lbs.	21,000
Beech............	"	11,500	Oak, Amer. white....	"	11,500
Cedar............	"	11,400	Oak, seasoned......	"	13,600
Elm............	"	13,400	Pine, "pitch,"......	"	12,000
Fir, strongest......	"	12,000	Teak, Java........	"	14,000
Lignum Vitæ....	"	11,800	Walnut...........	"	7,800

Miscellaneous Articles.

Brick.............	lbs.	290	Slate.............	lbs.	12,000
Ivory.............	"	16,000	Whalebone.......	"	7,600

Note—The practical value of the above is about one-fourth.

TO FIND THE STRENGTH OF DIRECT COHESION, EXPANSION BY HEAT.

RULE.—Multiply area of transverse section in inches by weight given in the preceding table—the product is the strength in lbs.

Example.—What is the strength of a bar of medium iron 2 inches square?

Transverse section of 2 inches=4 inches, multiplied by 50,000, equals 200,000 lbs., the answer required.

The absolute strength of materials pulled lengthwise, is in proportion to the square of their diameters.

100° of heat will expand a bar of cast iron .0006173 or the 1620th of its length.

100° of heat will expand a bar of wrought iron .0006614 or the 1512th part of its length.

The tensile strength of metals varies with their temperature, generally decreasing with increase of temperature.

The tensile strength of Iron and Steel Wire Ropes, is about 40,000 lbs. per inch area of Iron Rope and 80,000 lbs. per inch area of crucible steel Rope; or, 1 lb of Iron Wire Rope, 1 foot long, breaks at from 10 to 12 tons, and 1 lb. of Steel Wire Rope, 1 foot long, breaks at from 18 to 20 tons. One-sixth to one-seventh of the breaking strength of Iron and Steel Wire Rope, is considered a safe working load.

Iron and Steel Wire Rope for Hoisting.

For Deep Shafts, Incline Planes, or Slopes, Wire Rope is particularly well adapted; being so much lighter than other ropes or chain, requires proportionately less power to hoist it, and occupies less than

half the space on the drum. Its durability is from three to five times that of Hemp or Manila, and its weight is not increased or its fibres destroyed by working in wet situations.

As a practical illustration of the advantages of Iron Wire Rope over Hempen Rope, we submit the following :

Shaft 500 feet, Load including cage....................	3,000 lbs.
500 feet, 2 inch diameter, dry Hemp Rope weighs........	650 lbs.
500 feet, $\frac{3}{4}$ inch diameter, Iron Wire Rope.............	420 lbs.
Difference in favor of Wire Rope..................	230 lbs.

Allowing 1 minute hoisting time, then $\frac{500}{1} \times \frac{230}{2} = 57{,}500$ ft. lbs. = $1\frac{3}{4}$ horse power saved by using Iron Wire Rope.

The difference in favor of Crucible Steel Wire Rope is still greater, and may be summed up as follows :

1st. Crucible Steel Wire Rope is three times as durable as the best Manila or Hemp Rope.

2d. Crucible Steel Wire Rope weighs only four-tenths the weight of Manila of equal strength, when dry, and one-fourth when Manila or Hemp is wet.

3d.—Crucible Steel Wire Rope is only one-third the thickness of Manila of equal strength.

4th. Crucible Steel Wire Rope possesses more springiness or elasticity than any other kind of Rope.

5th. The first cost of Round Steel Wire Rope is 75 per cent. the first cost of Manila Rope.

From the above we invite Superintendents and Engineers of Mining Companies using rope, especially in deep shafts, to the following analysis of comparative cost, etc.

1st. Round Steel Wire Rope has been employed in California for over twelve years, in vicinities of Grass Valley, Downieville and Columbia, and the durability usually exceeds four times that of Manila.

2d. Take, for instance, a Manila Rope $2\frac{1}{4}$ inches thick, 1,000 feet of this size Rope will weigh about 2,200 lbs., *when dry*. Round Steel Wire Rope, same strength and length, will weigh 900 lbs., *wet or dry*. Difference in favor of Steel Rope, 1,300 lbs. For a 1,000-foot hoist, allowing two minutes, $\frac{1000}{2} \times \frac{1300}{2} = 325{,}000$ ft. lbs. = 10-horse-power; using say $\frac{1}{2}$ cord of wood at $6 per cord = $3 per day or $1,080 per annum, (360 days) expended in *hoisting up a dead weight of Manila Rope over that of Steel Rope.* Add to this the strain, wear and tear of

the machinery, and you will ascertain approximately what the present outlay is for hoisting ropes.

3d. The thickness of Round Steel Wire Rope being one-third that of Manila of equal strength, it takes proportionately less room on the winding drum ; thus 1,000 feet Steel Rope, ¾ in. in diameter, will wind on a drum five feet diameter and four feet long, with a *single* layer, while it will require *three layers* of Manila.

4th. Steel Wire Rope, although possessing more springiness in itself, does not *stretch out* like Manila, but takes back the spring it has given out. This elasticity relieves the dead strain on the rope, especially in case of sudden start of the hoisting engine.

SUMMARY:

Life of Manila Rope, say 4 months, equal 3 ropes for 1 year each rope costs, say $400		$1,200
Extra cost of fuel for hoisting dead weight, 1 year		1 080
Cost of 1 year running of Manila Rope	$	2,280
1 Round Steel Wire Rope equal to above 1 year		400
Annual saving effected by using Steel Wire Rope	$	1,880

We submit the above facts for your consideration and verification, modifying it to suit localities.

In applying Round Wire Rope the *groove* of the pulley over which the rope runs should be of the *same form and size* as the rope employed, and all drums and pulley sheaves should be 100 times the size of the rope for coarse ropes, or 60 times for flexible wire ropes.

Note—Within the past 10 years, Steel made by the Bessemer and Sieman-Martin processes has become quite popular, but it does not possess the value of refined crucible steel, and must not be confounded with it.

Tiller Ropes.

As a Tiller Rope for river steamers, it is superior to chain, being lighter, cheaper, and more easily managed, the objection caused by the links of the slack chain catching in the rollers—thus endangering the safety of the boat—is entirely removed.

Morever, in case of a fire on board, it is free from danger, while a Hemp or Raw Hide Rope, running as it does from one end of the boat to the other, is the first thing to become destroyed. With a Wire Rope, the pilot can stick to the helm as long as the fire will permit him.

Wire Cord,

For Hanging Sashes, Pictures, Dumb Waiters, Clock Weights, and for Signal Cord.

This Cord is made from iron, steel, copper, galvanized or composition wire, is very light, durable and pliable, and is not subject to rot. It has been in use for many years for the purpose of hanging window sashes, being much preferred to any other cord. No house should be without it. It is the only safe cord to use for hanging pictures or mirrors, as moths cannot attack it. (See List of Prices, on last page.)

Lightning Conductors.

Copper Wire Rope Lightning Conductors are much in use among the shipping, as a protection against the effects of lightning on a ship's mast. They are superior to any other conductor as a protection against lightning for church spires, tall chimneys, etc., are much more easily fixed, and do not get out of order. (See List of Prices, on last page.)

WIRE.

Telegraph Wire,
Fence Wire,
Bridge Wire,
Bessemer Spring Wire,
Brass Wire,
Charcoal Wire,
Stone Wire,
Bright Wire,
Tinned Wire,
Broom Wire,

Telephone Wire,
Baling Wire,
Steel Wire,
Copper Wire,
Lacquered Wire,
Flat Wire,
Annealed Wire,
Reaper Wire,
Grape Wire,
Training Wire

Special Wire, of various forms, made to order. All sizes from 000 to 40 constantly on hand and supplied to dealers on favorable terms.

Strength of Posts and Columns.

SAFE WEIGHT IN POUNDS PER SQUARE INCH FOR CAST IRON.

Length in diameters.	Hollow Cylinder.	Solid Cylinder.	Square + and T Sections
10	25759	18000	19800
20	12825	6800	8550
30	7200	3840	4800
40	4833	2610	3262

Thus a Solid Cylinder, 20 feet long, 1 foot diameter, will support safely 6800 lb. per square inch.

For Timber.

Length in diameters	10	20	30	40	50	60
Pounds per inch of section	900	600	336	229	143	100

A timber post 30 feet long, 1 foot diameter, will safely sustain 336 lbs. per square inch.

—*Whipple's Bridge Building.*

For obtaining the strength of Columns, Prof. Rankine gives the following formula:

$$P=\frac{f\quad s}{1+a\frac{l^2}{h^2}}$$

When P=breaking strength in lbs. s sectional area, l length, h least external diameter, all in inches, f and a constants having the following values for different materials.

	f	a
Wrought Iron	36000	.00033
Cast Iron	80000	.0025
Timber	7200	.004

Examples.

Required ultimate strength of hollow cylindrical cast iron column, 20 feet long, 10 inch external diameter, 1 inch thick.

$$P=\frac{(f)\ 80.000 \times (s)\ 28.28}{1+.0025\ \frac{(l^2)\ 240^2}{h^2\ \ 10^2}}=927.213 \text{ lbs.}$$

Required ultimate strength of rectangular timber post, 24 feet long, 10 inch x 10 inch.

$$P=\frac{(f)\ 7200 \times (s)\ 100}{1+.004\ \frac{(l^2)\ 288^2}{(h^2)\ \ 10^2}}=166,753 \text{ lbs.}$$

Required ultimate strength of solid wrought iron column, 18 feet long, 6 inches diameter.

$$P=\frac{36,000 \times 28.27}{1+.00033\ \frac{216^2}{6^2}}=712,848 \text{ lbs.}$$

The foregoing formula apply to columns with ends perfectly true, and carefully bedded and fixed. If ends are rough from the foundry, multiply value of 'a' by 4.

—*Vose's Manual for Railroad Engineers.*

CRUSHING STRENGTH OF VARIOUS MATERIALS, IN LBS. PER 1 IN. SQUARE.

Metals.

Cast Iron, American	129,000	Copper cast	117,000
Cast Iron, English	122,400	Steel cast	295,000
Wrought Iron, American	83,500	Tin cast	15,500
Wrought Iron, English	57,100	Lead cast	7,730

Woods.

Ash	6,663	Pine, pitch	8,947
Birch	7,960	Pine, white	5,775
Box	10,513	Spruce, white	5,350
Hickory, white	8,925	Teak	12,100
Oak, white	6,100	Walnut	6,645

Stones, etc.

Brick, hard	2,000 to 4,000	Marble	9,000 to 23,000
Brick, common	800 to 4,000	Mortar	120 to 240
Freestone, Conn.	3,319	Portland Cement 1, sand 1	1,280
Granite, Quincy	15,300	Sandstone	2,800 to 10,000

—*Haswell.*

Wire Rope as a Suspended Carriage Way

FOR DELIVERING ROCK, LUMBER, ETC., OVER OTHERWISE INACCESSIBLE POINTS.

There are many points in the mountains where it is impracticable to build a roadway, railway track, or chute. In such a place, a practical and economical method for delivering material is to extend a Wire Rope from the upper to the lower points when it is not too long for a single span, stretching it sufficiently tight to clear all points and obstructions, and on this Wire Rope to run a pulley, below which hangs a basket or box containing the rock—or if it is lumber, a pulley at each end of the lumber is necessary. In many cases in sending down rock, etc., it is found better to use three pulleys, two above and one below the rope, one of the upper pulleys being in advance and the other behind the lower one. By this means the pulleys are kept in the same direction as the rope.

The pulley should be of a large diameter, the groove to be of the same size as the rope.

The Endless Wire Ropeway system is adapted for delivering material across and over mountainous and difficult roads. (See page 25.)

Wire Cables for Suspension Flumes or Water Conduits,

For conveying water across deep gulleys, canyons, rivers, etc., with galvanized iron piping, joints, suspension rods, etc., etc., complete., —the most economical way of carrying water over a deep canyon, etc. Guaranteed to keep in perfect order. Estimates given and materials furnished low.

Wire Rope for Suspending Hydraulic Hose or Pipe clear of a Cave.

The high banks down which a hydraulic hose descends are very apt to cave and destroy the hose. In order to insure its safety, a Wire Rope is stretehed from the top of the bank to the bottom of the claim, at a sufficient angle to escape the bank in case of a cave. To this Wire Rope the hose is attached, and in such a position as to be perfectly secure from any danger of destruction by the caving of the bank.

The loss of one hydraulic hose would buy many Wire Ropes.

Iron and Steel Ferry Rope

Stretched across the river, being lighter, is more easily set up, and being perfectly round and smaller it allows the pulley blocks to run much freer and more rapidly over the rope, and removes the sudden strain caused by checking (as with a Hemp Rope), when the boat is in the centre of the stream, and does not require the contsant attention of the ferryman to set up or slack off the rope, according to the state of the weather; and as the sun does not rot it, it can be kept stretched during the Summer. Iron sheaves should not be used on Wire Ferry Rope, *unless the groove of sheave* properly fits the rope.

For a Swinging Ferry, where the rope lays in the water, it does not rot—nor does it, like Hemp, absorb the water until it becomes water-logged and clumsy. Hemp Rope, thus saturated, will have *four times* the weight of Wire Rope placed in the same position; thus in slack water, with Wire Rope, there is no useless expenditure of the force of the current in carrying the rope across; and consequently, smaller and lighter buoys are required.

N. B.—We have had Wire Ropes working as above for seven years.

Ferry Blocks furnished complete.

The Transverse Strength of Materials.

The transverse strength of any beam or bar of wood or metal is as the square of the depth multiplied by the breadth and divided by the length between the supports.

The transverse strength of any square beam of equal length, is as the cube of their depth—and that of cylindrical beams as the cube of their diameter.

The strength of a projecting beam is only one-fourth of what it would be if supported at both ends, and the weight applied in the middle.

The strength of a projecting beam is only one-sixth of what it would be if *fixed* at both ends, and the weight applied to the middle.

The strength of a beam to support a weight in the centre of it when the ends rest merely upon two supports, compared to one the ends being fixed, is as 2 to 3.

Ultimate strength of different materials, one inch square and one foot long, weight suspended from one end.

	Breaking weight.	Value for general use
Cast Iron	681	225
Wrought Iron, American	650	180
Wrought Iron, English	500	140
Wrought Iron, Swedish	665	182
Steel (extreme)	1918	400
Steel Puddled	800	190
Woods.		
Ash	168	55
Beech	130	32
Elm	125	30
Hickory	250	55
Oak, American white	230	50
Oak, American live	245	55
Oak, Canadian	146	36
Pine, Pitch	136	45
Pine, American	160	50
Teak	206	60
Stones.		
Freestone, Conn	13	4
Freestone, N. Y	24	8
Granite, Quincy	26	8½

Transverse strength of Cast Iron Bars of various figures, sections of each: 1 inch area, length 1 foot, fixed at one end, weight suspended at other.

Form of Section.	Breaking Weight.	Form of Section.	Breaking Weight.
Square...........	673 lbs.	Equilateral Triangle edge up........	560 lbs.
Square diagonal vertical......	568 "	Equilateral Triangle edge down.....	950 lbs.
Solid Cylinder ..	573 "	2 in. deep x 2 in. wide x .268 inch thickness	2068 "
Hollow cylinder outer diameter twice the inner.	794 "	2 in. deep x 2 in. wide x .268 inch thickness	555 "
Rectangle 2x½	1456 "		
3x⅓	2392 "		
4x¼	2652 "		

—*Haswell.*

RULE TO FIND THE TRANVERSE STRENGTH WHEN A RECTANGULAR BAR OR BEAM IS FIXED ON ONE END AND LOADED AT THE OTHER:

Multiply the *value* in the preceding table by the breadth and square of the depth in inches, and divide the product by the length in feet. The quotient is the weight in lbs.

N. B.—When the beam is uniformly loaded throughout its length, double the result.

Example.—What weight will a 2 in. square wrought iron bar bear, projecting 2 ft. 6 in. in length?

Value for wrought iron $180 \times 2 \times 2^2 = 1440 \div 2\frac{1}{2} = 576$ lbs.

WHEN THE BEAM IS FIXED AT BOTH ENDS AND LOADED IN THE MIDDLE.

RULE. Multiply the *value* in the preceding table by six times the breadth, and the square of the depth in inches, and divide by length in feet. The result must be doubled when its weight is evenly distributed along its length.

Example.—What weight will a bar of cast iron 2 in. square and 5 feet in length support in the middle, when *fixed* at the ends?

Value for cast iron $225 \times 2 \times 6 \times 2^2 \div 5 = 2{,}160$ lbs.

WHEN THE BAR OR BEAM IS SUPPORTED AT BOTH ENDS AND LOADED IN THE MIDDLE.

RULE. Multiply the *value* in the preceding table by the square of the depth, and four times the breadth in inches, and divide the result by the length in feet.

Note.—When the weight is uniformly distributed, double the result.

Example 1. What is the weight a cast iron bar 5 feet between the supports and 2 inches square will support?

Value for cast iron $225 \times 2^2 \times 2 \times 4 = 7{,}200 \div 5 = 1{,}440$ lbs.

Example. How much will an ash beam support, being 10 feet between supports, 8 inches deep by four inches wide.

Value for ash, $55 \times 8^2 \times 4 \times 4 = 56{,}320 \div 10 = 5{,}632$ lbs.

TO FIND THE DIMENSIONS OF A BAR OR BEAM TO SUPPORT A GIVEN WEIGHT IN THE MIDDLE, BETWEEN FIXED ENDS.

Multiply the length between the fixed ends in feet by the weight, and divide the product by 6 times the *value* of the material; the result will give the product of the breadth and square of the depth.

Example. What are the necessary dimensions of a beam of American pine, 20 feet long, to support a load of 15,360 lbs.

$$\underset{\text{lbs.}}{15{,}360} \times \underset{\text{ft.}}{20} \div 6 \times 50 = 1024 \div \underset{\text{Assumed breadth.}}{4} = 256.$$

$$\sqrt{256} = 16 \quad \text{size should be } 4 \times 16$$

Note.—In above example the result is 1,024, which divided by the assumed breadth, 4 in., will leave 256, being the square of the depth 16, or by dividing the result 1,024, by the square of the depth (16^2)= 256, gives the breadth 4 in.

Steel Wire Rope for Derrick Fall Ropes

Works to great advantage, especially if the hoisting is done by water or steam-power. The sheaves are made of cast iron 10 to 14 inches diameter, the groove of which conforms to the size of the rope—for ordinary work, a Steel Rope ½ inch thick is sufficient for the purpose. A Fall of this kind properly put on, will outlast five or six Manila Falls, and occupy one-sixth the space on the drum.

Wire Rope for "Derrick Guys."

The universal adoption of the derrick for working deep claims in the river bars, etc., in preference to any other method, being much cheaper, and more expeditious, has drawn attention to its erection, and to the necessity of keeping the derrick *mast* in its proper position. With Manila Guy Ropes this is impossible. The constant stretching and shrinking of Hempen Ropes require the almost constant slacking and tightening of them, according to the state of the atmosphere; and when the mast leans out of its position, it is almost impossible to swing the boom to its proper point.

Wire Rope being unaffected by the weather, this trouble and expense is saved; being 40 per cent. lighter, it is much more easily and more tightly set up ; and as the sun does not rot and destroy its fibres by its being exposed to the summer heat, it will last an incredibly long time.

Wire Rope for River Mining.

For Pump Ropes, especially if of a great length, the advantage of using Wire Rope is obvious. A Grip Pulley, (see pages 37 and 38) is fixed to the shaft of the water wheel and pump, a Wire Rope is used to transmit the power. (See page 49.) The fact that when spliced and put on the grip pulleys, the Wire Rope does not stretch and allow the pump to stop working, is a matter of very great moment to the river miner, saving him an immense amount of trouble and care ; and those who have once experienced the loss of time and money by the filling up with water of a large and deep pit, can more fully appreciate this.

Specific Gravities—Weight of Substances.

Water is well adapted for the standard of gravity. A cubic foot of rain water weighs 1,000 ounces, avoirdupois, and its weight is taken as the unit.

When a body is immersed in water, it loses such a portion of its own weight as is equal to that of the fluid it displaces.

Following is a list of specific gravities of various substances:

Metals.		Metals—Continued.	
Brass Plate	8380	Mercury, 60°	13580
Brass Wire	8214	Nickel	8008
Copper Plates	8698	Platinum, native	16000
Copper Wire	8880	Platinum, hammered	20337
Gold, pure cast	19258	Silver, pure cast	10474
Gold, 22 karat fine	17486	Silver, pure, hammered	10511
Iron, Cast	7207	Steel Plates	7806
Iron, Wrought Bar	7788	Steel Wire	7847
Iron Wire	7774	Tin, pure	7291
Lead, Cast	11352	Zinc, cast	6861
		Zinc, rolled	7191

Dry Woods.

Ash	722
Birch	567
Cedar	561
Cherry	715
Ebony, American	1331
Elder	695
Elm	600
Fir	512
Hickory, pig nut	792
Hickory, shell bark	690
Lignum Vitæ	1333
Locust	728
Mahogany, Honduras	560
Mahogany, Spanish	852
Maple	750
Maple, Birdseye	576
Oak, Canadian	872
Oak, English	932
Oak, Heart, 60 years	1170
Oak, Live	1068
Oak, White	860
Pine, Pitch	660
Pine, White	554
Spruce	500
Sycamore	623
Teak	700
Walnut	671
Walnut, Black	500
Willow	530

Stones, Earth, Etc.

Asphaltum	905 to 1650
Borax	1714
Brick	1367 to 1900
Brick, Fire	2201
" Work, in cem't	1800
" " in mort'r.	1600 to 2000
Cement, Portland	1300
Clay	1930
Clay, with Gravel	2480
Coal, Newcastle	1270
Coal Scotch	1259 to 1300
Coal, Anthracite	1436 to 1640
Earth, common soil.	2194
Granite, Quincy	2652
Limestone	3180
Marble, Italian, wht.	2708
Quartz	2660
Salt, Common	1670
Slate	2672 to 2900
Sulphur, Native	2033
Trap	2720

Liquids.

Oil, Linseed	940
Oil, Olive	915
Oil, Petroleum.	878
Water, rain	1000

Divide the specific gravity of any of the above substances by 16, and the result will be the weight of 1 cubic foot in pounds.

Transportation of Ore and Other Material

BY MEANS OF ENDLESS TRAVELING WIRE ROPES.

HALLIDIE'S PATENT ROPEWAY.

The system of transporting material by means of an endless traveling wire rope has been well and thoroughly tested during the past six years under a variety of circumstances, which have proved its economy, simplicity, and advantages.

The "Endless Ropeway," introduced in the year 1871, and protected by numerous U. S. patents granted to me, has been in operation for six years, and proved itself in every way the most reliable, economical, and simple mode of conveying ores, rock, earth, lumber, produce, and material of all description, that can be conveyed in reasonable size packages over difficult roads, or over roads inaccessible to the most economical and rapid mode of steam locomotion.

During the past six years, many very valuable improvements have been made in the details of construction, reducing the cost of the same and simplifying its operations.

The principles of its operations will bear the strictest criticism, and an examination of the same by skilled and scientific mechanics, will demonstrate the great advantages over the many methods now in operation for similar purposes.

Its mode of operating may be briefly summed up as follows:—

An endless wire rope is supported at intervals of from 150 to 200 feet, on grooved wheels or sheaves, which are secured to the ends of cross-arms, elevated on suitable posts or towers, about 16 feet above surface obstruction of the ground; the bights of the endless rope are placed around end sheaves or grip pulleys, placed horizontally, one at each extremity of the line. The endless rope thus passed around

horizontal end sheaves or grip pulleys, and is supported between these end sheaves at proper intervals, on bearing sheaves of such proportions that the friction is reduced to a minimum.

The office of the end, or "grip" pulley, is to transmit power to or from the endless rope, so that the rope cannot slip in the groove of the pulley, and the speed of the rope can be regulated by it.

The conveyers or carriers used for moving the material, the form of which is regulated by the character of the material to be moved, are attached to the rope by means of steel clips of peculiar form, at distances regulated by the amount of the material to be moved.

It will be seen that when the rope is set in motion, either by gravitation or by other motive power, it will carry with it the carriers or conveyers at such rate of speed as may be determined to be most suitable.

These are so arranged that they pass over the bearing sheaves and around the end or grip pulleys. At any point in the line of the Ropeways the carrier can be loaded or discharged. The rope runs at an uniform rate of speed, about 200 feet per minute; and the carriers are loaded as they pass, and at the point of discharge are unloaded automatically.

When the point of discharge is lower than the point of loading, the Ropeway will run by gravitation, if the angle of descent exceeds 8 degrees, or 1 in seven. When it is less than eight degrees, power has to be employed, and this can be attached anywhere on the line—either steam, water or other motor. Where the line runs by gravitation, brakes are attached to the end grip pulleys, and the speed thus regulated, and at the same time the line is under the control of the man in charge.

For conveying ore from the mine to the mill, the carriers are wrought iron rectangular buckets, holding 100 lbs. ore, and are self-dumping.

If the rope travels at 200 ft. per minute and the ore buckets are 100 ft. apart and hold 100 lbs. each, there will be delivered 200 lbs. of ore every minute, or 6 tons per hour, or 60 tons per day of 10 hours—this is about as much as two men can conveniently shovel into a cart, and for an ordinary line run by the gravitation of its descending load, this is all the attendance necessary. One of the men should go over the line once a day and see that the journals are properly oiled.

For a line one mile long, running by gravitation and delivering 60 tons per day, the cost of delivering ore is under 15 cents per ton, as follows :

Two men at $50 per month	$100 00
1¼ per cent. wear and tear	75 00
10-12 per cent. interest on cost	50 00
Oil, etc	5 00
Cost per month	$230 00

Sixty tons per day for 26 days per month=14¾c. per ton.

By placing the buckets 50 feet apart, the amount of ore carried will be doubled, or 120 tons per day of 10 hours—or by running 20 hours per day the same result will be obtained—in both cases the men required for loading will be doubled, but the cost of carrying the ore will be reduced to about 10c. per ton per mile.

When the angle of descent is very great, the descending load furnishes sufficient power to carry back and up to the mine such material as may be needed—and in several lines I have constructed, this saving, when taken into account, has been so great that it has not only brought the cost of transporting the ore to nothing, but has been actually a source of revenue.

Again, in cases where a limited power is needed at the mine for pumping, etc., the power can be supplied from the mill by means of the grip pulleys and the endless wire rope.

In brief, the foregoing system is *applicable* for the following purposes:

For conveying ores from the mine to the mill.

For conveying light loads of any material from place to place.

For transporting produce and lumber across difficult points, and to shipping in an offing.

For conveying passengers across gorges, chasms and over hazardous roads.

For supplying water to reservoirs across chasms, etc.

The *advantages* claimed are:

No grading or road-building is required.

It can work under all circumstances of weather, with great depths of snow on the ground, during heavy storms and freshets.

It can run constantly without rest ; as well during a dark night as a clear day

It can cross deep gorges and chasms.

It can pass around precipitous bluffs and perpendicular cliffs, or over the most rugged mountains.

The rope can never leave the posts or sheaves.

It can furnish and transmit power, when there is sufficient descent, by its own gravitation, or by an engine attached to either end.

It can be constructed and worked cheaper than any other system or road can be constructed and worked under like circumstances.

By using the Duplex Carrier, it can convey any material, such as lumber, goods, ores and passengers, from place to place.

The letters and extracts herewith appended speak for themselves :

EUREKA, Nevada, July 10th, 1872.

T. M. MARTIN—*My Dear Sir:* On your leaving for San Francisco, it gives me great pleasure to hand you my written acceptance of the HALLIDIE TRAMWAY, put up by you on our mine in Freiberg.

It is a perfect success, discharging ten tons of ore per hour, with two men's labor. It is perfectly simple in construction, and as far as I can judge, there is nothing about it to ever get out of order—nothing to wear out. While ours requires but about 2,500 feet of Wire Rope, I could see no reason why the line could not be extended almost indefinitely with equally happy results. Again, the carrying capacity might be doubled or quadrupled if desired. After several weeks trial upon our mine, the unanimous verdict of all who have seen it, is a complete, unquestioned success. If this can be of any service to you, use it in any way you think proper.

Very respectfully,
C. C. GOODWIN.

EMMA HILL CONSOLIDATED MINING CO.,
LITTLE COTTONWOOD, Utah.
Superintendent's Office, Sept. 28, 1872.

T. M. MARTIN, Esq.—*Sir:* The Ropeway constructed by you (HALLIDIE'S PATENT) for the Emma Hill Consolidated Mining Company, has been built in a most substantial and workmanlike manner, and is at this time in splendid working condition. I most cheerfully accept the work for the company, and recommend it to others wishing a sure and speedy transit for ores over places impracticable for wagon roads, etc.

Respectfully,
L. U. COLBATH,
Superintendent.

[From the Utah Mining Journal, Salt Lake, Sept. 23d, 1872.]

THE VALLEJO ROPEWAY.

The Vallejo Tunnel Company's Tramway in Little Cottonwood, built on the HALLIDIE PATENTED PLAN, is a complete success. It is between 2,300 and 2,400 feet in length, and is supported by thirteen stations. The fall in this distance is about 600 feet, and the Wire Rope, which is five-eighths of an inch in diameter, will safely and easily deliver 100 tons in six hours. The machinery

is automatic, loading and unloading the sacks or buckets. The stations are about 200 feet apart, and the entire apparatus is strong and safe. As the Wire Rope is elevated about 40 feet above the surface of the hill, the Tramway can be worked all winter long, without the slightest trouble.

Office of the Chicago Silver Mining Co.,
Salt Lake City, Dec. 1, 1874.

A. S. Hallidie, Esq.—*Dear Sir:* I have pleasure in stating that your Ropeway, put up at the Chicago Mine, Ophir District, Utah Territory, one year ago last summer, has been in constant use ever since, and with the most satisfactory results.

The line, as you are aware, is constructed over an extremely rugged country, one and one-quarter miles in length.

For the first mile or so, it is down a very steep mountain side, whence it passes over the brow of another one; thence it continues down Dry Canyon at an angle of 15 to 18 degrees.

The structure is an entire success, the cost entire of which has more than been saved already, although it has not been worked up to half its capacity.

In the estimate of earnings no account was taken of supplies sent to the mine, including water, etc., by no means an inconsiderable item.

Truly yours,

W. S. GODBE,
Manager Chicago S. M. Co. (Limited.)

Superintendent's Office,
Emma Hill Consolidated M. Co.,
Little Cottonwood, Utah, Dec. 17, 1874.

A. S. Hallidie, Esq.—*Dear Sir:* In answer to your inquiry, I have to report that the Ropeway (built August, 1872) continues to work splendidly, and with but little wear on the rope. It has been everything that was promised, and has proved to be the cheapest way to move ores on steep mountain sides.

Yours very truly,

L. U. COLBATH,
Superintendent.

Kernville, Kern County,
California, May 6th, 1878.

A. S. Hallidie, Esq.—*Dear Sir:* Your Patent Wire Ropeway, which I recently erected at the Harley Mine, near this place, works entirely satisfactorily, effecting a great saving in the cost of transporting ore from the mine to the mill, and in sending lumber and supplies to the mine. The cost of transporting the ore by pack train was five dollars per ton—by your ropeway, it does not exceed fifty cents. The length is one mile and a half, the upper end having an elevation of over 3,000 feet above the lower end. It crosses a high canyon at a height of over 300 feet from the surface of the ground with a single span of 750 feet; and, altogether, the ground is among the roughest in the Sierra Nevadas.

Respectfully yours,

A. BLATCHLY, M. E.

Chemical Laboratory and General Mining Offices,
504 Washington St., San Francisco, May 15th, 1878.

A. S. Hallidie, Esq.—*Dear Sir:* In answer to your inquiry about the "Wire Ropeway," erected by my advice, for the Blue Jacket Mining Company, Bull Run District, Elko County, Nevada, I have pleasure in stating that, under the following conditions, it works surpassingly well, and transports the ore by its own weight without other power, for nearly a mile, over a rough, descending grade of 11 degrees from the mine to the mill, at a cost of about 20 cents per ton; thereby saving at least $2 per ton, compared with horses.

Yours respectfully,
J. S. PHILLIPS.

Office of Standard Gold Mining Co.
San Francisco, Oct. 8, 1878.

A. S. Hallidie, Esq.—*Dear Sir:* The Ropeway you erected for us in December, 1877, has now been in use over nine months, and has given very great satisfaction, enabling us to transport our ore from the mine to the mill, a distance of half a mile, without interruption, and during all kinds of weather. We send over the line forty-seven tons per day of seven hours, and the saving, over the old method of hauling, is fully seventy-five per cent. In addition to the important fact of being able to get our ore regularly, regardless of the weather, we can send back water lumber, etc., without cost.

The expense of running the line, bringing down the ore, repairs, &c., is about ten dollars per day.

We are well satisfied with the manner in which it works.

JOHN H. BOYD,
Vice-President.
WM. WILLIS,
Secretary.

Figure One. General View of Ropeway

GENERAL SUGGESTIONS

FOR ERECTING

HALLIDIE'S ROPEWAY.

In determining the route it is better to avoid vertical angles, *i. e.* as a rule to go over a hill (if it be not too great) rather than around it, and make the line as direct as possible, and in a true line, avoiding unnecessary angles. The general appearance of the Ropeway is shown in the large engraving on the preceding page.

Upper Terminus.

In locating the upper terminus (at the mine) it is important to be as near the tunnel's mouth as possible. The horizontal grip pulley should be far enough below the level of the tunnel to enable sufficient ore to be dumped into the bin to keep the line running for a few days.

A hopper-shaped ore bin is constructed, into which the ore is dumped from the mine; at the lower end it is supplied with a gate that permits about 100 lbs. of ore to pass out (at a time, or enough to fill one of the ore boxes of the Ropeway, the ore is allowed to run out of the mouth of the hopper) into a scoop that is attached to a swinging arm, that swings around the shaft of the grip pulley, and while the traveling ore boxes on the rope are passing, the scoop travels with it and dumps its load into the ore box; or the ore can be simply shoveled into the traveling ore boxes as they pass by.

The grip pulley should therefore be placed—say 20 feet below bottom of tunnel. The frame that carries the grip pulley is constructed as shown in the diagram annexed, Fig. 2. The grip pulley shaft must be vertical, and guide pulleys lead the rope fair into the grips of the pulleys—(these guide pulleys are placed as near to the grip pulley as possible); the frame must be well anchored to a good foundation.

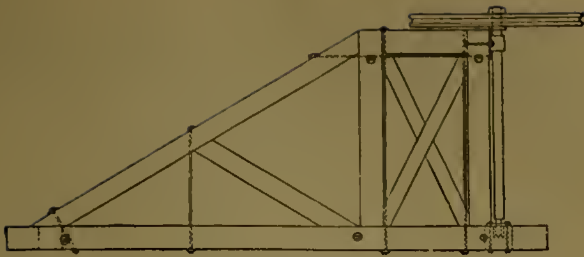


Figure 2.
SIDE ELEVATION OF UPPER GRIP PULLEY FRAME.

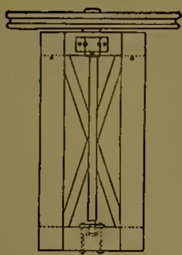
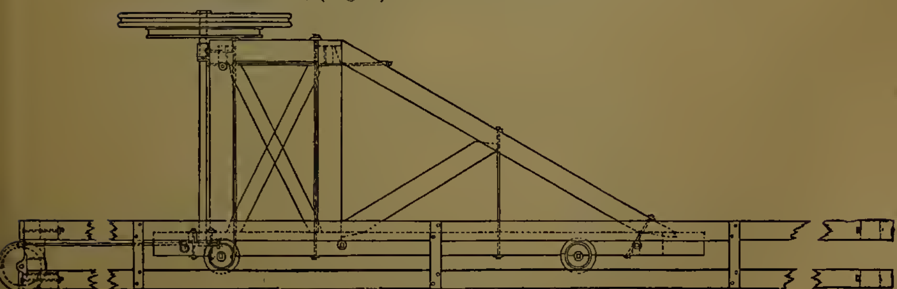


Figure 3.
END ELEVATION OF UPPER GRIP PULLEY FRAME.

Lower Terminus.

The lower terminus should be located at, or beyond the point where the ore is required to be dumped, and the grip pulley frame should be at sufficient elevation to prevent the ore backing up over the track. If the ore is to be trans-shipped, then an elevated hopper-shaped bin, with escape gates at the lower end will be most convenient—or, the ore can be dumped at any suitable point on the line of the Ropeway.

The grip pulley frame is constructed in the same manner as for the upper terminus, but the frame is placed on heavy car wheels that run on a suitable track, (Fig. 4).



SIDE ELEVATION OF LOWER GRIP PULLEY FRAME.
Figure 4

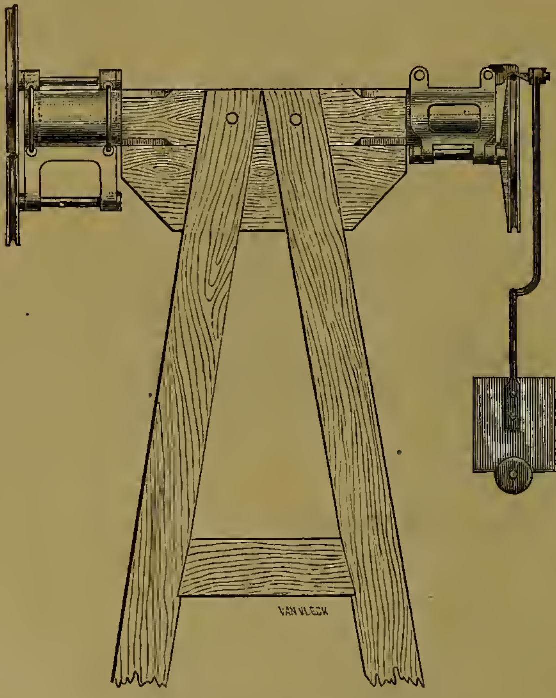
There should be allowed about thirty-five feet travel to each Rope-way, in order to cover the contraction, expansion and stretching of the rope. A weight is attached to a wire rope, working over a pulley, the other end of which is secured to the grip pulley frame. By this means a constant tension is kept on the line.

In all cases the grip pulleys should be set horizontally.

At the point where it is desired to dump the ore, the ore buckets pass between guides and a stop knocks open the catch, (which holds the bottom in place) as the bucket is passing, causing it to drop its load ; a counter balance attached to the bottom causes it to close again—the guides are either of scantling or bar iron.

Stations.

About 150 feet apart, between the two termini, are constructed frames called stations, from 14 to 50 feet high, according to circumstances, made from four sticks, which form a pyramid or tower, as shown in Fig. 5.



STATION-FRAME – SIDE-ELEVATION.

Figure 5.

It is desirable to place the center of these towers in a true line, from shaft to shaft of grip pulleys of termini. In a long line this can not always be done, and sometimes angles have to be formed to pass around bluffs. In such cases the centre line should pass from angle to angle. Or, again—it is necessary to pass around a curve of large radius; in this case the sheaves of the stations are so arranged that the rope leads fair into them and is slightly deflected after leaving the sheaves. This will be explained under the head of angles. At the top of these frames, at right angles to the line of the Ropeway, there is a cross arm usually of 8x8 timber; the length of the arm being about equal to the diameter of the grip pulley. The cross arm is well secured to the frame so as not to twist out of position. At the extremities of the cross arm are fitted cast iron frames that carry the bearing and guide sheaves.

The ends of the cross arm are rounded off to eight inches diameter, and the cast iron frames are secured to them by means of bolts in the cast iron frames, which clasp the ends of the arms. (See Fig. 6.)

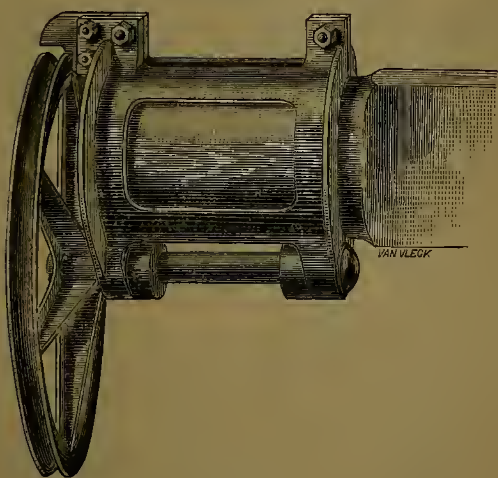


Figure 6.

The object in having the ends of the cross arm round, is to enable the cast iron station frames to be adjusted to the horizontal angles formed by the rope as it passes on to and off from the bearing sheaves. It must be provided that the station sheaves are so arranged that the rope always runs on them, *fairly in line.*

As the rope, when traveling, tends to pull the end of the cross arm in the direction it is running, the importance of having these arms well braced to resist this tendency will be understood.

The station frames in some cases carry two sheaves, an upper and a lower one, the object of the upper one being to prevent the rope jumping out from its place in the groove of the lower sheave. When the rope runs with a constant downward strain on the lower pully, a guard of cast iron is placed over the sheave to keep the rope in place, and the upper sheave is dispensed with, as shown in Fig. 6, and this latter is the method now generally adopted, except when the rope is apt to have an upward strain.

Some judgment must be exercised in locating the stations, and usually the higher points are selected, for the reason that shorter towers have to be built and the rope is not diverted so much from its natural curve.

Occasionally it is necessary to hold the rope down much below the point it would naturally sag; in such a case the larger sheave has only a quarter groove, and it is placed above; the smaller sheave has a full grove, and is placed below. See Fig. 5, left hand cross arm. But such cases are rare, and it is better to make a span of 300 or 400 feet between stations.

The configuration of the ground will in all cases determine the height of the stations. If the ground is free from projections and obstructions, the height should not be less than 15 feet, where the stations are 150 feet apart, increasing in height with the distance between the stations. Considerations of depth of snow, crossing wagon roads, etc., must not be forgotton.

Stations should be well secured to the ground, to resist gales, etc.

After the stations and grip pully frames are up, see that all the bearings are well oiled and the working parts run free; that the brake wheels of the grip pulleys work well, and that all your work so far is secure.

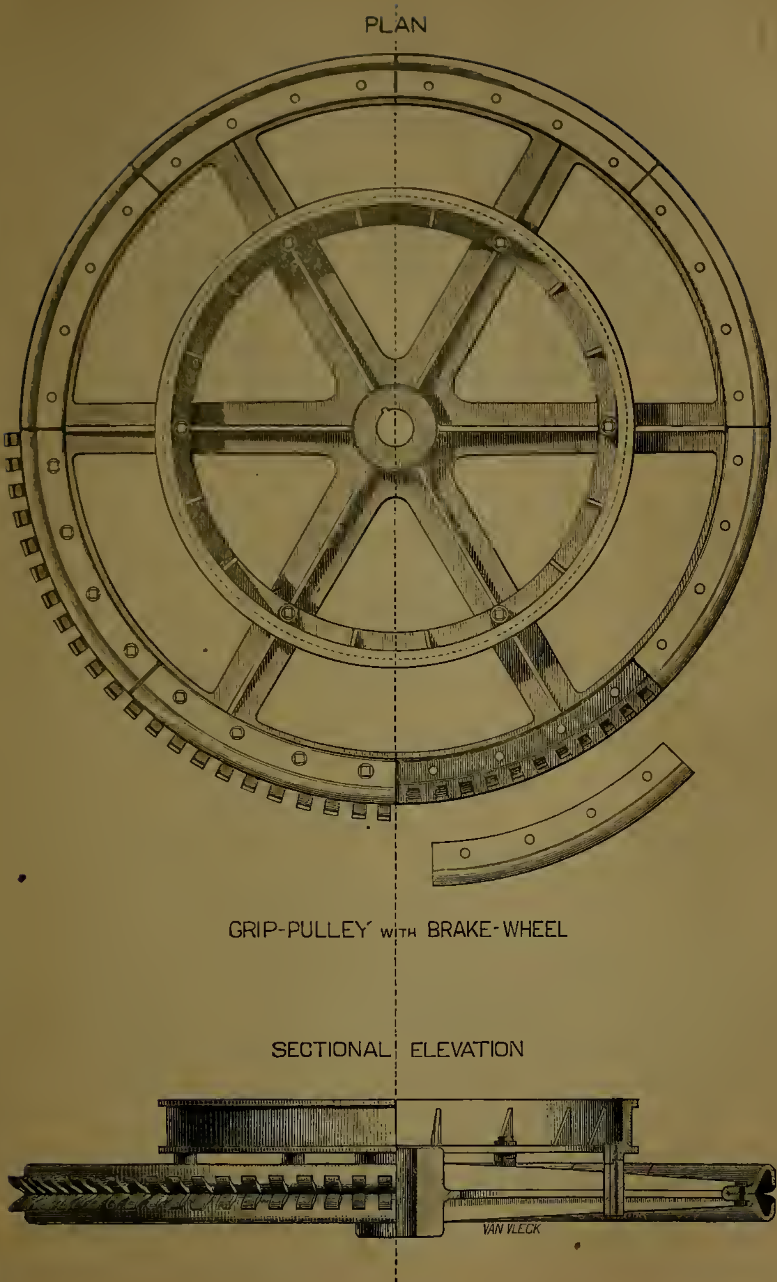

PLAN
GRIP-PULLEY WITH BRAKE-WHEEL
SECTIONAL ELEVATION
VAN VLECK

Fig. 7.

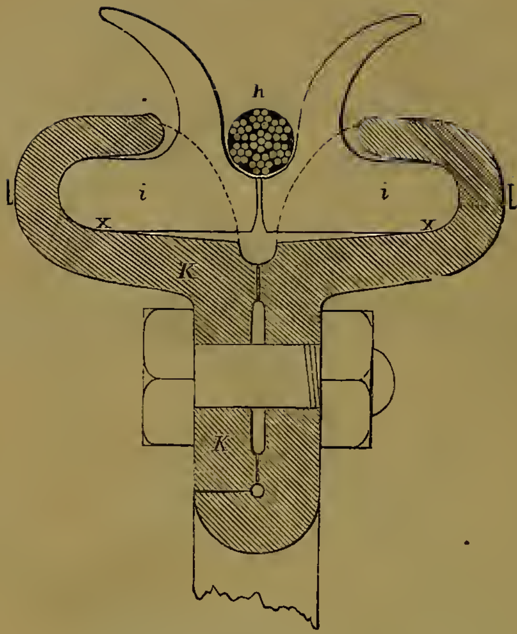


Figure 8.

Grip Pulleys.

For light lines, grip pulleys are usually six feet in diameter, keyed to a shaft 3½ inches in diameter, that runs in a step at the lower end, and a box at the upper end, under the pulley. Bolted to the arms of the grip pulley, above it, is a brake-wheel with brake-band, furnished with adjusting screw and hand-wheel. (See Fig. 7.) The brake is used in regulating the speed of the Rope-way, or stopping the same, when it runs by gravitation. Figure 8 is a section of the rim of the Grip Pulley, showing the grips and mode of working. *h* is the rope which presses on the gripping jaws *i i* which rests on the points *x x* of the rim of the wheel *L L*.

When the line is level and runs by power this brake is dispensed with.

Stretching the Rope.

The Wire Rope for an ordinary line of one mile length is usually five-eighths of an inch diameter and made of crucible steel wire.

The coil, if not on a reel, is placed on a temporary turn table, and the outer end is led through the sheaves from station to station, until the coil is exhausted ; great care must be taken to prevent any kink getting in the rope—in order to prevent this, it is better to have the rope put on a reel.

If the Ropeway is short, say one-half mile, the rope will probably be in one piece, and may be made of charcoal iron. The two ends are brought together at a place convenient for splicing, and by means of blocks and tackle, the rope is hauled up taut, and the point of joining is marked by tying opposite each other a stop on each rope. The mode adopted for splicing is as follows :

Splicing the Rope.

There is about eighty-four feet of rope required to put in a good smooth long splice. The wire ropes employed in these Ropeways are made six strands of seven wires each, and a core or heart; as there are two rope ends to splice together, there will consequently be twelve strands to be tucked in. Operators usually tie the stops that mark the length of rope, about where the center of the splice will be. In this case the usual way is to unlay each rope up to that point, and place the strands of rope A between the strands of rope B, the core or heart of the ropes A and B, being cut off so that the cores of the ropes abut against each other. (See Fig. 9.) There will be then forty-two feet of strands each side of the stop, thus:

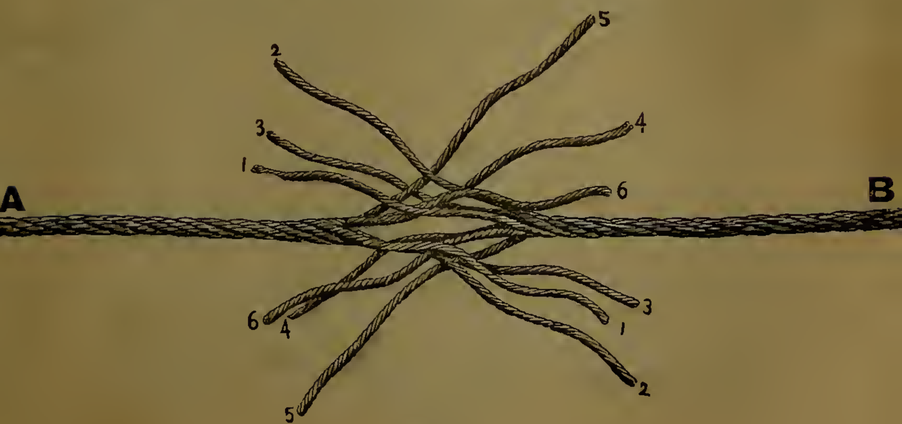


Fig 9.

It is important that each strand should be in its proper place, so that none of them cross other strands, or that two strands be not where one strand should be (by placing your fingers between each other in natural position, this will be understood). Then strand No. 1 of rope A is unlaid, and strand No. 1 of rope B follows close, and is laid snugly and tightly without kink or bend in its place, until within seven feet of the end, a temporary seizing is then put on securing ropes and strands at this point. Strand No 1 of rope B is then cut off, leaving it seven feet long. Then strand No. 2 of rope A is unlaid and, strand 2 of rope B is laid in its place to within twenty-one feet of its end. Strand No. 3 of rope A is unlaid, and strand No. 3 of rope B is laid in its place, within thirty-five feet of end. By this time you have reached within seven feet of the center, and reversing the operation, unlay strand No. 4 of rope B, and lay in its place strand No. 4 of rope A, to within seven feet of its end; unlay No. 5 of rope B, and lay in No. 5 of rope A, to within twenty-one feet of its end; finally, unlay No. 6 of rope B, and lay in its place No. 6 of rope A, to within thirty-five feet of its end. The strands are now all laid in their places and seized down for the time being, the ends are cut off, as with the first strand, to seven feet in length, and present the appearance, as in Fig. 10.

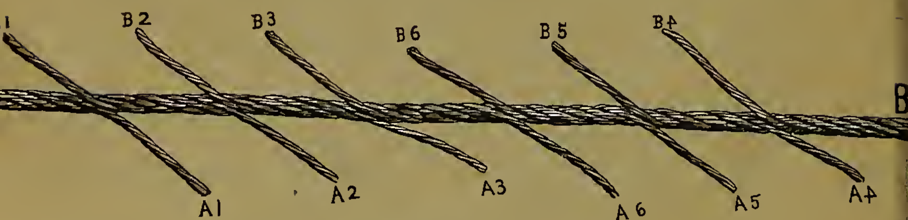


Fig. 10

The next opperation is to tuck in the ends, and we will proceed to tuck in B 1. It will be remembered that the ropes are made of six strands, laid around a core or heart, usually of hemp, of the same size. Two clamps (Fig. 11) made for this purpose, are fastened on the rope so as to enable the operator to untwist the rope sufficiently to open the strands and permit the core to be taken out (see diagram) which is cut

Fig. 11.

away, leaving a space in the center of the rope; the strand B 1, is placed across A 1, and put in the center of the rope in place of the extracted core, forming in fact a new core. A flat-nosed T- shaped needle used in splicing, the point of which is about one-half inch wide by three-sixteenths of an inch thick, rounded off to an edge, is well adapted to this purpose. The strand B 1 is laid in its entire length, the core being cut off exactly at the extremity of strand B 1, so that when the rope is enclosed around the inserted strand, the ends of the strand and core should abut. If there is much space left in the center of the rope without a core, the rope is liable to loose its proper form and some of the strands fall in, exposing the projecting strands to undue wear. The same operation is performed with A 1, running the other way of the rope, and so on, until all the strands are tucked in, which, if properly done, will leave the rope as true and round and as strong as any other part.

Other operators prefer to start from the end of one rope and consequent end of splice. The operation is about the same, but the experience of the writer justifies him in saying that more care has to be used in bringing all the strands to an even tension in the parts spliced. Other variations in detail are made according to the fancy or practice of the splicer, but after making a few successful splices in manner above described, the operator can afterwards vary to suit himself.

The rope is now spliced into an endless rope, and is in position between the station sheaves, and around the end grip pulleys, so that by turning the grip pulleys at either end the rope should travel freely.

Attaching the Clips.

The next thing is to place the clips and hangers on the rope; the number of clips to be placed on the rope depends upon the amount of ore to be conveyed, and if it is conveyed in ore sacks, a simple hook, or a L-shaped platform is attached to the clip, so that the ore sack may be hooked or laid on. Usually the mode of conveying the ore is by means of rectangular sheet iron boxes, the bottoms of which are on hinges, with counter-balances to close up the bottom and a catch to release or retain it. These boxes hold 100 lbs. of ore The clips are made of the best steel of the following shape. (See Fig. 12, page 42.)

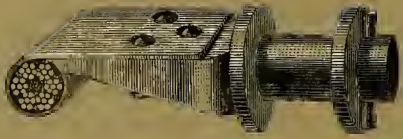


Figure 12.

The thin part is warmed and opened thus (See Fig. 13):

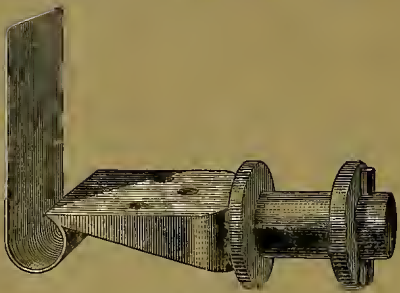


Figure 13.

so that the rope can be slipped into it, the thin plate being immediately closed over and enveloping the same. The thin plate is drawn over to its place tightly by driving a punch into the rivet holes, and the rivets are then put in and rivetted up. It is thus closely secured to the rope, and capable of sustaining a very heavy load, the peculiar form of the clip enabling it not only to clasp but to rest on the rope.

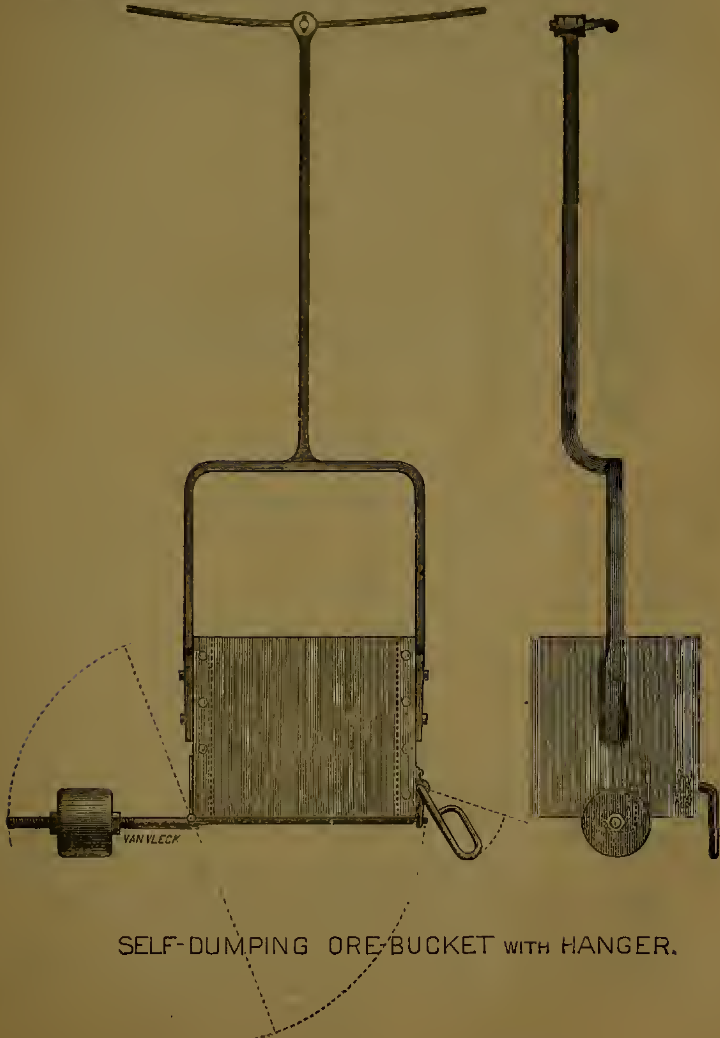
The outér washer is removed from the turned part of the clip and the eye of the hanger of the ore-box is slipped on; the washer is then put back and the pin driven in to secure the same. The ore box is now on, ready for use. It will be observed that the hanger of the box has a short bend in it; this is to compensate for the projection of the clip. The ore box is made of sheet iron, and the bottom is hinged at one end, the other end being held in place by means of a keeper, which has a projecting arm. As the loaded bucket passes the place where the ore is to be delivered, the projecting arm strikes a stop, which throws the keeper off the catch, releases the bottom of the ore box, and dumps the ore; a counter-balance attatched to the bottom closes the ore box and it is then ready for reloading. (Figure 14 is a side view, and Figure 15 an end view of the ore bucket.) The clip will naturally hang at right angles to the line of the hanger, which is plumb or vertical when it is at rest. (See Figs. 5 and 15.) In same manner the remaining clips and ore boxes are put on. In no case leave the clip without a hanger, as it is liable to turn over and get foul between the station sheaves.

Direction the Rope should Travel.

In the absence of any reason to the contrary, the rule in regard to

the direction the rope should travel, is, that the right hand rope recedes from you, as you look towards it, but it can be made to run either way.

When the line has any descent, the most convenient place to put on the clips and boxes, is at the upper end—right hand of the grip pulley. In a gravitation line, by loading the boxes, as they are put on, they faciliate the moving of the rope.



SELF-DUMPING ORE-BUCKET WITH HANGER.

Fig. 14. Fig. 15.

The Ropeway is now ready to put in motion, and if the angle of descent is sufficient, say eight degrees, it will deliver its load to the mill by gravitation, and carry back to the mines light loads, such as tools, provisions and a fair amount of drift timber.

The ore boxes being self dumping at the lower terminus, require no attendance, and one man can run a line of ordinary length—however, the machinery has to be oiled and kept in order, and a man should pass over the line to oil and examine the station sheaves, the grip pulley gear, etc., every day.

The rope should be kept well tarred (Sweedish tar and linseed oil, 4 parts to 1, boiled together, should be used), and all running parts kept from rusting.

No good mechanic need be told that it pays to construct work well, and to take care of it afterwards.

Vertical Angles.

In long lines, sharp angles have sometimes to be formed around bluffs, or the line may have to be diverted so as to reach various desirable points, either to discharge or receive ores, or to utilize water power, etc. In these cases the angle is made by using horizontal sheaves of about six feet diameter. A single sheave, placed horizontally, makes the angle of the rope, on which the clips project outward; but to make the angle of the rope where the clips project inward, two sheaves are required. See upper Fig. 16.

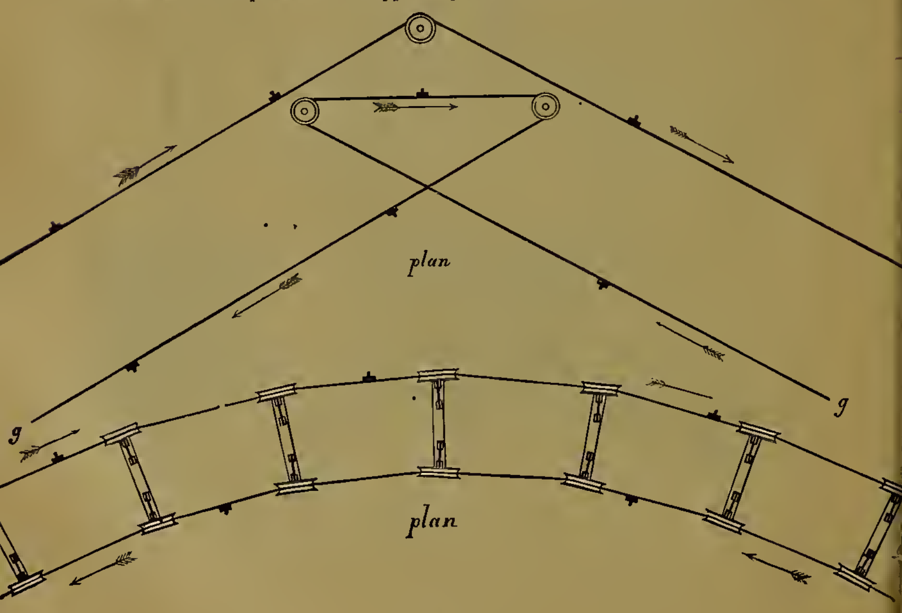


Fig. 16.

The two sheaves of the interior angles must be placed at different levels, so that at the point of intersection of the rope, one part of the rope will be sufficiently high above the other part to permit the ore box to pass over it, say seven feet, and the sheaves must be set so that the rope leads fair on to them.

When the angle is but a few degrees, and of great radius, a series of stations are placed continuous to each other, the sheaves of which are placed so that the *rope leads on them fairly*, and is deflected slightly after leaving the sheaves in the direction of the angle desired. See lower diagram Fig. 16.

To Transport Heavy Loads.

When it is necessary to transport loads heavier than 200 lbs. on a rope five-eighths inch diameter, the number of clips may be increased, and placed from two to four feet apart, as shown in Fig. 17.

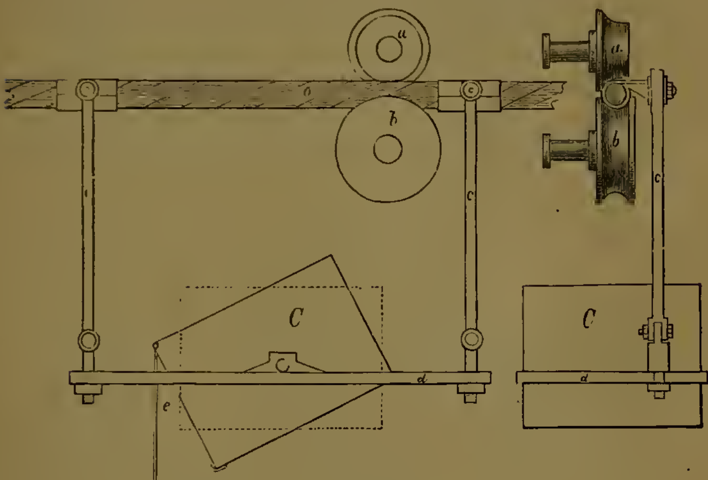


Figure 17

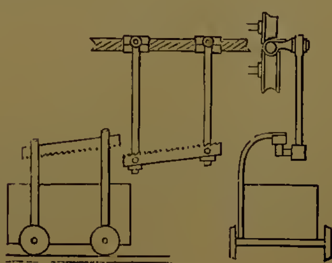


Figure 18.

A car is shown in Fig. 18, which may be found very useful in certain cases, as it economizes in manual labor. A small car is mounted on wheels, so that it can be run into the mine. It has a carrying frame above, the longitudinal beam of which is inclined, so as to correspond with that of the standard. Both are toothed, the former on its lower, and the latter on its upper side. Now, if the car be run into position when the standards, which are attached to the rope, come around, they will catch and carry off the car without any manual labor, and at the discharging point the car strikes an incline, which raises it sufficiently high to clear the toothed beam. The teeth on the beams prevent any slipping.

Estimates furnished, contracts entered into, or reliable men sent to superintend construction.

For further information, address the patentee,

A. S. HALLIDIE, P. O. Box 2050,

San Francisco, Cal.

Secured under U. S. Patents Nos. 100,140, 110,971, 115,309, 115,310, 121,776, 124,391, 127,690, 143,087, 162,915, and applications now pending.

Velocity of Water in Pipes and Sewers.

Table of the heads of water necessary to maintain different velocities of water in 100 feet of pipe.

V represents the velocities in feet per minute, and *C* the constant number for those velocities.

V	*C*	*V*	*C*	*V*	*C*
60	8.62	90	17.95	140	38.90
70	11.40.	100	21.56	150	44.
80	14.58	120	29.70	180	62.13

Table of the constant number for different velocities.

D represents diameter of pipe, in inches, and *c* the constant number for their diameters.

D	*c*	*D*	*c*	*D*	*c*
4	.028	6	.078	8	.134
5	.053	7	.104		

Rule. Then when H represents the head of water $\frac{c}{D \times C} = H$.

Example. It is required to determine what head of water would be necessary to send water through 1500 feet of six-inch pipe, to an elevation of 80 feet, and at a velocity of 180 feet per minute.

C=62.13÷(6+0.078) 6.078=10.22 in. which × 15 (the number of 100 feet) =153.3 in. (12 ft. 9 in.) this added to 80 gives 92 ft. 9½ in., answer.

The time occupied in an equal quantity of water through a pipe or sewer of equal length and with equal falls, is proportionately as follows: In a right line, as 90, in a true curve, as 100 and in a right angle as 140.

Velocity of Streams and Resistance of Soils.

Ordinary nature of current.	Velocity In Feet per Sec.	Velocity In Miles per Hour.	Materials that resist these velocities and yield to more powerful ones.
Very Slow..................	0.25	0.171	Wet Ground—Mud.
Gliding.............. ..	0.50	0.341	Soft Clay.
Gentle....................	1.00	0.682	Sand.
Regular......	2.00	1.364	Gravel.
Ordinary velocity	3.00	2.046	Stony.
Rapid Floods..............	3.35	2.284	Broken Stones, Flints etc.
Rapid Floods, (extraordinary).	3.50	2.380	Collected Boulders, soft Schistose.
Torrents and Cataracts	9.86	6.723	Hardened Rock.

Blasting.

In small blasts 1 lb. powder will loosen 4½ tons.

In large blasts 1 lb. powder will loosen 2¾ tons.

One man can bore with a bit 1 inch diameter from 50 to 100 inches per day of 18 hours, in granite, or 300 to 400 inches per day in limestone.

Two strikers and a holder can bore with a 2 inch bit 10 ft. per day in rock of medium hardness.

At the depth of 45 feet the temperature of the earth is uniform throughout the year.

Overshot Water-Wheel.

Rule to ascertain Power.—Multiply the weight of water, in lbs., discharged upon the wheel in one minute, by the height or distance, in feet, from the lower edge of the wheel to the center of the opening

in the gate; divide the product by 50,000, and the quotient is the number of horses' power.

Example. Suppose the weight of water discharged per minute is 39,000 lbs. If the height of the fall is 23 feet, the diameter of the wheel is 22, what is the power of the wheel?

22 feet less 8 inches clearance below=22' 4"=22.33. 39,000× 22.33=870,870÷50,000=17.41 horse-power.

Rule to ascertain Velocity of Water and Weight per minute, in pounds, discharged on Overshot Water-wheel.—Extract square of height of head of water (from surface to middle of gate) and multiply by 8 if the opening is large and head small; if the reverse, multiply by 5.5; or, from 8 to 5.5 in proportion to size of opening and head of water.

Example. The dimensions of the stream are 2 by 80 inches, with a head of 2 feet to upper surface of water. What is the velocity of the water per minute?

2 feet plus half of 2 ins.=25 ins.=2.08, the square of which is 1.44 ×6.5(estimate of velocity)=9.36×60=561.60 feet.

What is its weight?

Example. 80 inches×2×6739.20 inches (=561.60 feet)= 1,078,272÷1728 (inches in a cubic foot)=624 cubic feet×62½ lbs. (weight of cubic foot of water) =39,000 lbs. weight discharged in one minute.

To Find the Quantity of Water which will Flow Out of an Opening.

Rule.—Multiply the square root of the depth of the water by 5.4; the product is the velocity in feet per second; this multiplied by the area of the opening in feet will give the number of cubic feet per second.

Example. If the centre of an opening is 10 feet below the surface of the water, and its area is 2 feet, what quantity of water will run out in one minute?

$\sqrt{10}$=3.16×5.4×2=34.1496 feet= (34 1-7 feet.)

Water will fall through 1 foot in ¼ second, 4 feet in ½ second, 9 feet in ¾ second, and so on—being actuated by the same laws as falling bodies

Transmission of Power by Wire Ropes.

Transmission of Power by Means of Wire Rope.

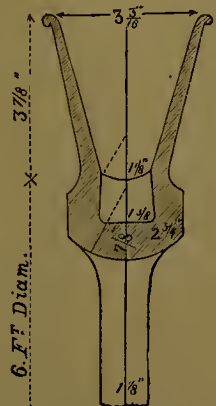
Wire Rope is employed extensively for conveying power from one point to another, as in the case of a mill situated half a mile or so from the water wheel from which power is obtained, and has been found to be very economical and durable. In France and Germany Wire Rope is used wherever an economic motive power exists and can be attached, in many cases there being 5 or 6 miles between the motive power and the machinery to be set in motion. Considerable attention is now paid to this method of transmission, and the economy and simplicity of its application are very strong recommendations in its favor. The manufacture of flexible ropes from steel wire, having great strength, with lightness and elasticity, insures the extensive application of this system. Evidently the power which can be transmitted by this plan, under given positions, depends upon the adhesion existing between the rope and the pulley, and the amount of this adhesion determines the velocity of motion of the rope, in order to transmit any given power. When, by a peculiar construction of the pulley, the adhesion is made equal, or nearly so, to the strength of the rope, the velocity of the rope can be made to be quite slow, while at the same time transmitting great power. This is done by means of Grip Pulleys, where the rims of the pulleys are made up of a great number of *clips* operating on the principle of the toggle joint, to clamp the rope firmly between them while they are drawn down together by the force of the strain that is put upon the rope. As soon as the rope is released from strain, the clips open readily for its free escape as it leaves the pulley. From experiments made with Grip Pulleys of this construction, which have been patented, it has been ascertained that the gripping power varies with the angle at which the clips are set, and is from 40 to 100 times the strain of the slack rope, or of the rope paying on from the slack side. The shape of that part of the clip which receives the rope is the same as that of the rope, and since there is no slipping of the rope between the clips, the wear upon it when in use is very slight. By reference to figs. 7 and 8, pages 37 and 38, the operation of the clips will be readily understood.

The rope is denoted by *h; i, i* are clips working on a fulcrum *xx.* The rope pressing on the clips at the bottom, as it enters them, causes them to close over it, gripping it securely and preventing its slipping. The part of the rim, *k*, is cast separately and bolted to the main wheel, *l*, by a bolt. The rim of the wheel is cast with recesses to take the clips, fitting to them and allowing them to work freely; while the clips cannot possibly be displaced except by

removing the part *k*, which is cast separate for this purpose. From this it will be readily understood that the rope is grasped as soon as the pressure begins to act on the clips, and is released as soon as the pressure is removed, the whole acting automatically and invariably. For *conveying power* over long distances, this feature is of the greatest value. In this system the rope is made of strength sufficient for the transmission, and moves at velocity of from 300 to 800 feet per minute.

With the high speed system the rope is of smaller size, and travels at a velocity of from 1,500 to 6,000 feet per minute. In order to prevent the too rapid wear of the rope, the high speed pulleys are made with gutta percha seating for the rope. A dovetailed groove is made in the rim of the pulley, into which the gutta percha is forced in the shape of small blocks, dovetailing on the sides, and having a score on the top. When the groove is filed with these blocks, they present a firm and elastic seat for the rope, giving the greatest adhesion possible under the circumstances; or, instead of using gutta percha blocks, hard rubber belting may be used, being cut in strips of sufficient depth for the dovetailed groove of the pulley, and placed side by side, so that the rope will run on the edge of the rubber belting. The strips are driven in tight and held together by being glued.

The accompanying cut shows the mode of constructing the high speed pulleys, and the advantage these have over the grip pulley is, that a much smaller rope can be used, the proportion being as the velocity of the rope.



In many places in France and Germany, vast amounts of power are transmitted. At Shaffhausen, Switzerland, the water-fall is economized through an overshot water-wheel, and by means of Wire Rope, 600-horse-power is transmitted for a distance of one mile, and thence distributed by means of other smaller Wire Ropes to various factories. The whole Pacific Coast is full of water-powers, and a knowledge of

this mode of transmission of power will make many of these water privileges available.

A table of dimensions and velocities has been inserted, which will be found convenient for reference in ascertaining the size and speed of ropes and pulleys, to transmit any given power, either by high speed and smooth pulleys, or by low speed, and the patent grip pulleys.

Transmission Pulleys.

APPROXIMATE TABLE OF DIMENSIONS AND VELOCITIES.

	HIGH SPEED.					LOW SPEED.				
Horse Power	Circumference of Ropes. Steel.	Circumference of Ropes. Iron.	Speed of Ropes in feet per minute	Diameter of wheel . . .	Revolutions of wheel . . .	Circumference of Ropes. Steel.	Circumference of Ropes. Iron.	Speed of Ropes in feet per minute	Diameter of wheel	Revolutions of wheel . . .
2	¾ in	1 in	1000	4	80	1 in	1½ in	400	4	32
3	⅞ in	1⅛ in	1000	4	80	1 in	1½ in	600	4	48
4	⅞ in	1⅛ in	1250	4	100	1¼ in	1⅝ in	400	4	32
5	⅞ in	1⅛ in	1500	4	120	1¼ in	1⅝ in	500	4	40
6	⅞ in	1⅛ in	1750	4	140	1¼ in	1⅝ in	600	4	48
8	1⅛ in	1⅜ in	1570	5	100	1½ in	2 in	509	6	27
10	1⅛ in	1⅜ in	1880	5	120	1⅝ in	2⅛ in	603	6	32
15	1¼ in	1½ in	2260	6	120	1⅞ in	2¼ in	416	6	22
20	1¼ in	1½ in	2420	7	110	2 in	2½ in	506	7	23
25	1¼ in	1½ in	2640	7	120	2⅛ in	2¾ in	502	8	20
30	1⅜ in	1⅞ in	2750	8	120	2⅛ in	2¾ in	603	8	24
40	1⅝ in	2 in	2260	9	80	2¼ in	2⅞ in	424	9	15
50	1⅝ in	2 in	2820	9	100	2¼ in	3 in	509	9	18
60	1⅝ in	2 in	3400	9	120	2⅜ in	3¼ in	502	10	16
80	1¾ in	2⅛ in	3800	10	120	2⅜ in	3¼ in	597	10	19
100	1¾ in	2⅜ in	3200	12	85	2½ in	3½ in	603	12	16
120	1⅞ in	2⅝ in	3260	13	80	3 in	3¾ in	603	12	16
150	2 in	2½ in	3620	14	80	3¼ in	4 in	616	14	14
200	2 in	2½ in	5280	14	120	3⅞ in	5 in	704	14	16
250	2¼ in	2¾ in	4710	15	100	4 in	5½ in	704	16	14
300	2¼ in	2¾ in	5650	15	120	4¼ in	6 in	704	16	14

In practice for a distance less than 40 or 50 feet, there is not much economy in using Wire Rope, and the span between the pulleys should not exceed 400 feet; without supporting pulleys, which should not be smaller than the driving or driver pulley, and should also be rubber lined.

Instead of supporting pulleys at intervals of from 150 to 400 feet according to circumstances, and a long rope; in some cases it is more advantageous to use a series of endless ropes and double pulleys, the ropes being much shorter are more easily repaired.

For mode of splicing transmission ropes, see pages 39—40.

Patent Grip Pulleys.

These pulleys are made expressly for the purpose of transmitting power by means of Steel or Iron Wire Ropes.

By referring to the diagrams on pages 37 and 38, figs. 7 and 8, and the description on same pages, their mode of action can be readily understood.

By means of these Grip Pulleys, it is possible to transmit power from one point to another, and to the limit of the strength of the rope employed.

It will thus be seen that this arrangement is adapted for conveying power from a waterfall in a river, or where there is a large stationary engine, to any point desired, one, three or five miles distant, the Wire Rope being supported on pulleys at intervals in order to keep the rope off the ground, and lead it in the proper direction.

As a means of transmitting power from a portable steam engine to a threshing machine it enables the farmer to keep his steam engine sufficiently far from the grain to avoid conflagration.

It is the most economical and convenient mode of transmitting power, and is available for innumerable cases, and any locality, as the rope *cannot slip* in the groove, and the pulley does not wear the rope, as a concave drum, capstan, or figure of 8 pulley does.

For hoisting works in a mine where a car is attached to both ends of the rope, for an incline, vertical or horizontal shaft, it is admirably adapted, economizing in machinery and wear of rope.

For steam plowing by means of ropes it works to great advantage, being much simpler in its action than any form of pulley.

For transmitting power to rope traction, or cable street railroads, the Grip Pulleys are well suited, The Clay Street Hill R. R. Co. employs two Grip Pulleys, side by side, for working their rope, on their incline of 1 in 9, 11,000 feet long, carrying 8,000 to 10,000 passengers per day.

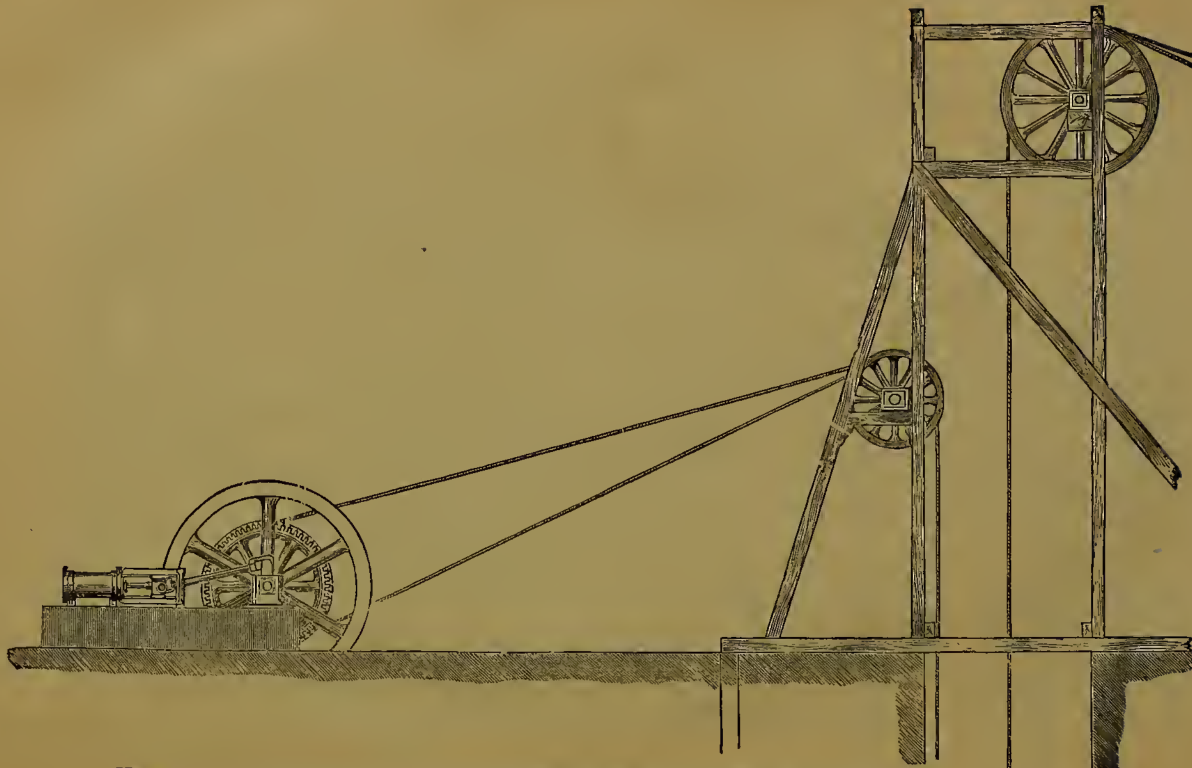
These pulleys are made all sizes, but the size of the grip pulley should not be less than 1,000 times the size of the wire from which the rope is made, or about 100 times the size of the rope.

Accompanying cuts show the application of these pulleys for various purposes.

Price of Patent Grip Pulleys.

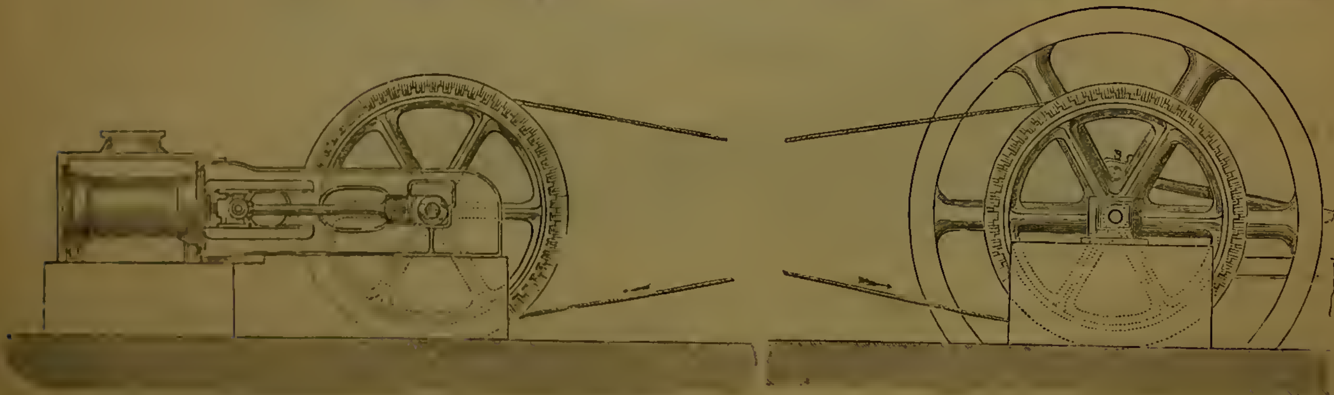
Diameter, feet	3	4	5	6	7	8	9	10
Price,	$30	$50	$80	$125	$150	$200	$280	$320

For Ropeways a special kind of Wire Rope is manufactured.

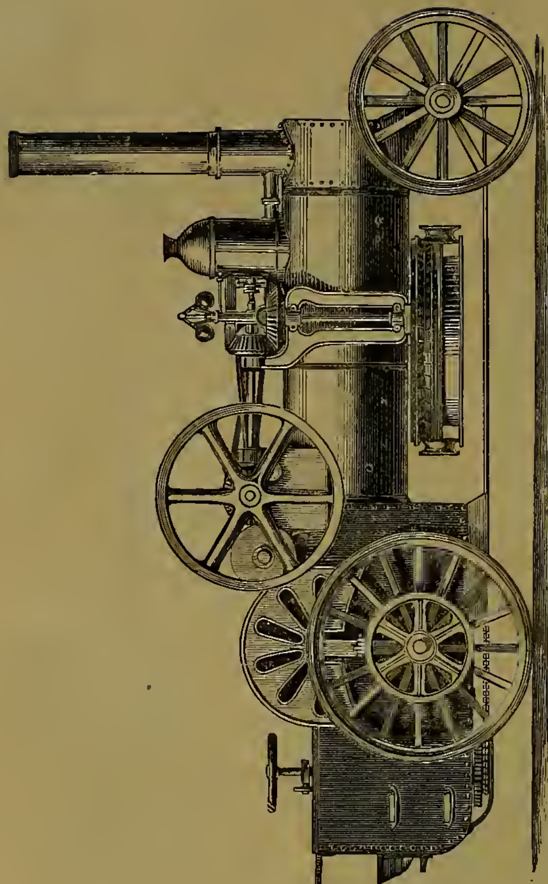


Hoisting Engine showing Grip Pulley working hoisting rope in vertical shaft, or transmitting power to lower levels.

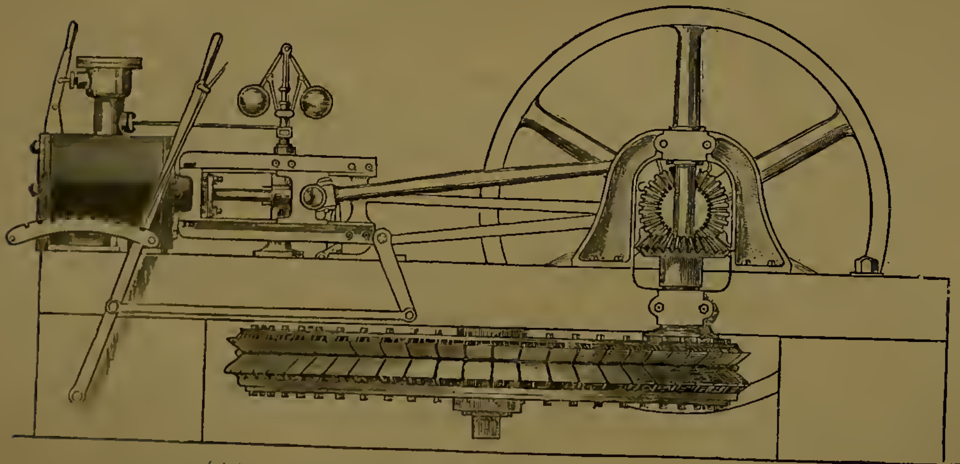
Application of Grip Pulley for Hauling and Lowering Ore Cars on Inclines.



Application of Grip Pulleys for Transmitting Power.



Portable Steam Engine with Grip Pulley, for Transmitting Power, Steam Plowing, etc.



Stationary Steam Engine with Horizontal Grip Pulley attached.

Weight per square foot of sheets of different metals. Thickness by Sharp & Brown's Guage.

GUAGE	Thickness INCH.	Wrought Iron. LBS.	Steel. LBS.	Copper. LBS.	Brass. LBS.
0000	.46	18.4575	18.7036	20.838	19.688
000	.40964	16.4368	16.6559	18.5567	17.5323
00	.3648	14.6376	14.8328	16.5251	15.6134
0	.3248	13.0351	13.2088	14.7162	13.904
1	.2893	11.6082	11.7629	13.1053	12.382
2	.2576	10.3374	10.4752	11.6706	11.0266
3	.2294	9.2055	9.3283	10.3927	9.8192
4	.2043	8.1979	8.3073	9 2552	8.7445
5	.1819	7.3004	7.3977	8.2419	7.787
6	.1620	6.5011	6.5878	7.3395	6.9345
7	.1443	5.7892	5.8664	6.5359	6.1752
8	.1285	5.1557	5.2244	5.8206	5.4994
9	.1144	4.5915	4.6527	5.1837	4.8976
10	.1019	4.0884	4.1428	4.6156	4.3609
11	.0907	3.641	3.6896	4.1106	3.8838
12	.0808	3.2424	3.2856	3.6606	3.4586
13	.0712	2.8874	2.9259	3.2598	3.0799
14	.0641	2.5714	2 6057	2.903	2.7428
15	.0571	2.2899	2.3204	2.5852	2.4425
16	.0501	2.0392	2.0664	2.3021	2.1751
17	.0452	1.8159	1.8402	2.0501	1.937
18	.0403	1.6172	1.6387	1.8257	1.725
19	.0359	1.44	1.4593	1.6258	1.5361
20	.0312	1.2824	1.2995	1.4478	1.3679
21	.0285	1.142	1.1573	1.2893	1 2182
22	.0253	1.017	1.0306	1.1482	1.0849
23	.0226	.9057	.9177	1.0225	.96604
24	.0201	.8065	.8173	.91053	.86028
25	.0179	.7182	.7278	.81087	.76612
26	.0159	.6396	.6481	.72208	.68223
27	.0142	.5696	.5772	.64303	.60755
28	.0126	.5072	.514	.57264	.54103
29	.01126	.4517	.4577	.50994	.4818
30	.0100	.4023	.4076	.45413	.42907
31	.00893	.3582	.363	.40444	.38212
32	.00795	.319	.3232	.36014	.34026
33	.00708	.2841	.2879	.32072	.30302
34	.0063	.2529	.2563	.28557	.26981

For comparative thickness of guage, see page 58.

Weight of Bar Iron.

Square, from 3/8 to 2 1/2 inch, and 1 foot long.

Size in Inchs.	Wght in Lbs.	Size in Inchs.	Wght. in Lbs.	Size in Inchs.	Wght in Lbs.	Size in Inchs.	Wght. in Lbs
3/8	.475	7/8	2.588	1 3/8	6.390	1 7/8	11.880
1/2	.845	1	3 380	1 1/2	7.604	2	13.520
5/8	1.320	1 1/8	4.278	1 5/8	8.926	2 1/4	17.112
3/4	1.901	1 1/4	5.280	1 3/4	10.352	2 1/2	21.120

Round Bar from 3/8 to 2 1/2 inches diameter and 1 foot long.

Diam'tr.	Wt. in lbs	Diam'tr.	Wght. in lbs.	Diam'tr.	Wght in Lbs.	Diam'tr.	Wght in Lbs.
3/8	.373	7/8	2.032	1 3/8	5.019	1 7/8	9.333
1/2	.666	1	2.654	1 1/2	5.972	2	10.616
5/8	1.043	1 1/8	3.360	1 5/8	7.010	2 1/4	13.440
3/4	1.493	1 1/4	4.172	1 3/4	8.128	2 1/2	16.680

Flat Bar from 3/4x1/8 to 5x1 and 1 foot long.

Size in Inchs.	Wght. in Lbs.	Size in Inchs.	Wght. in Lbs.	Size in Inchs.	Wght. in Lbs.	Size in Inchs.	Wght in Lbs
3/4x1/8	0.316	1 3/4x1/4	1.479	2 1/2x1/4	2.112	3x1	10.138
3/4x1/4	0.633	1 3/4x3/8	2.218	2 1/2x3/8	3.168	3 1/2x1/4	2.957
3/4x3/8	0.950	1 3/4x1/2	2.957	2 1/2x1/2	4.224	3 1/2x3/8	4.436
7/8x1/8	0.369	1 3/4x5/8	3.696	2 1/2x5/8	5.280	3 1/2x1/2	5.914
7/8x1/4	0.738	2x1/4	1.689	2 1/2x3/4	6.336	3 1/2x5/8	7.393
1x1/8	0.422	2x3/8	2.534	2 3/4x1/4	2.323	3 1/2x3/4	8.871
1x1/4	0.845	2x1/2	3.379	2 3/4x3/8	3.485	3 1/2x1	11.828
1x3/8	1.267	2x5/8	4.224	2 3/4x1/2	4.647	4x1/4	3.380
1 1/4x1/8	0.528	2x3/4	5.069	2 3/4x5/8	5.803	4x1/2	6.759
1 1/4x1/4	1.056	2 1/4x1/4	1.900	2 3/4x3/4	6.970	4x3/4	10,138
1 1/4x3/8	1.584	2 1/4x3/8	2.851	3x1/4	2.535	4x1	13.518
1 1/2x1/8	0.633	2 1/4x1/2	3.802	3x3/8	2.802	5x1/4	4.224
1 1/2x1/4	1.266	2 1/4x5/8	4.750	3x1/2	5.069	5x1/2	8.449
1 1/2x3/8	1.900	2 1/4x3/4	5.703	3x5/8	6.337	5x3/4	12.673
1 1/2x1/2	2.535	2 1/2x1/4	2 112	3x3/4	7.604	5x1	16.897

To convert into weight of other metals, multiply the above for cast Iron by .93; for Steel × 1.01; for Copper × 1.15; for Brass × 1.09; for Lead × 1.48; for Zinc × .92.

Length of Cut Nails and Number in one Pound.

	3d	4d	5d	6d	8d	10d	12d	20d	30d	40d
Length	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	$3\frac{1}{2}$	4	$4\frac{1}{4}$
No. in Lbs....	420	270	220	175	100	65	52	28	24	20

Measure of Rock, Earth, Etc.

25 cubic feet of sand equal 1 ton.

18 cubic feet of earth equal 1 ton.

17 cubic feet of clay equal 1 ton.

13 cubic feet of quartz, unbroken in lode, equal 1 ton.

18 cubic feet of gravel or earth, before digging, equal 27 cubic feet when dug.

20 cubic feet of quartz broken (of ordinary fineness coming from the lode), equal 1 ton contract measurement.

Table showing Size, Weight and Length of Iron Wire (Worcester Gauge).

Gauge Nos.	Diameter Inches.	Area Square inch.	Ultimate Strength in lbs.	Weight of 100 feet. lbs.	Wt. of 1 mile. lbs.	Feet in 63 lbs. Feet.	Feet in 2,000 lbs. Feet.
0000	.393	.121300	9,704	40.94	2163.	154	4,885
000	.362	.102900	8,232	34.73	1834.	181	5,759
00	.331	.086040	6,883	29.04	1533.	217	6,886
0	.323	.081930	6,754	27.66	1460.	228	72,30
1	.283	.062900	5,032	21.23	1121.	296	9,425
2	.263	.054320	4,345	18.34	968.	343	10,905
3	.244	.046759	3,741	15.78	833.	399	12,674
4	.225	.039760	3,181	13.39	707.	470	14,936
5	.207	.033653	2,692	11.35	599.	555	17,621
6	.192	.028952	2,312	9.73	514.	647	20,555
7	.177	.024605	1,968	8.03	439.	759	24,906
8	.162	.020612	1,648	6.96	367.	905	28,734
9	.148	.017203	1,376	5.08	306.	1,086	34,483
10	.135	.014313	1,144	4.83	255.	1,304	41,408
11	.120	.011309	904	3.82	202.	1,649	52,356
12	.105	.008659	693	2.92	154.	2,158	68,493
13	.092	.006647	532	2.24	118.	2,813	89,286
14	.080	,005260	421	1.69	89.	3,728	118,343
15	.072	.004071	328	1.37	72.	4,598	145,985
16	.063	.003117	248	1.05	55.	6,000	190,476
17	.054	.002290	184	.77	41.	8,182	259,740
18	.047	.001734	138	.58	31.	10,862	344,827
19	.041	.001320	105	.45	24.	14,000	444,444
						Ft. in 12 lb	
20	.035	.000963		.32	17.	3,750	625,000
21	.032	.000803		.27	14.	4,444	740,741
22	.028	.000615		.21	11.	5,714	952,381
23	.025	.000491		.17	9.	7,059	1,176,500
24	.023	.000415		.14	7.4	8,571	1,428,580
25	.020	.000314		.11	5.8	10,909	1,818,180
26	.018	.000254		.085	4.5	14,117	2,352,940
27	.017	.000227		.076	4.0	15,790	2,631,580
28	.016	.000201		.067	3.54	17,910	2,986,560
29	.015	.000176		.059	3.11	21,340	3,390,000
30	.014	.000154		.052	2.75	23,080	3,846,150
31	.013	.000133		.045	2.38	26,666	4,444,444
32	.012	.000113		.038	2.00	31,600	5,263,160
33	.011	.000095		.032	1.69	37,500	6,250,000
34	.010	.000078		.026	1.37	46,154	7,692,310
35	.0095	.000071		.024	1.27	50,000	8,333,333
36	.009	.000064		.022	1.16	54,545	9,090,909
37	.0085	.000057		.019	1.03	63,160	10,526,520
38	.008	.000050		.017	.897	70,600	11,764,700
39	.0075	.000044		.015	.792	80,000	13,333,333
40	.00725	.000041		.014	.739	85,715	14,285,710

The strength of the wires on the preceding page is taken at 80,000 lbs. per square inch ; and the table of ultimate strength, is for hard or bright wire. Annealing or softening reduces the tensile strength about 40 per cent.

For the guidance of those using or requiring wire for particular purposes, the following table of the different guages in use, may be of advantage:

Nos.	WORCESTER. Diameter.	TRENTON. Diameter.	BIRMINGHAM. Diameter.	Brown & Sharp. Diameter.
	Inches.	Inches.	Inches.	Inches.
0	.323	.305	.331	.32486
1	.283	.285	.300	.28930
2	.263	.265	.280	.25763
3	.244	.245	.260	.22942
4	.225	.225	.240	.20431
5	.207	.205	.220	.18194
6	.192	.190	.200	.16202
7	.177	.175	.185	.14428
8	.162	.160	.170	.12849
9	.148	.145	.155	.11443
10	.135	.130	.140	.10189
11	.120	.1175	.125	.09074
12	.105	.105	.110	.08080
13	.091	.0925	.095	.07196
14	.080	.080	.085	.06408
15	.072	.070	.075	.05706
16	.063	.061	.050	.0508
17	.054	.0525	.045	.0452
18	.047	.045	.040	.0403
19	.041	.038	.035	.0359
20	.035	.033	.030	.03196

The Gauge in use at my Wire Mills is the Worcester Guage.

In ordinary wire when great accuracy is requisite, the *diameter* desired should be given.

STREET RAILROADS

WORKED BY

ENDLESS TRAVELING WIRE ROPES

While Mr. Hallidie was engaged in maturing his system of endless wire Ropeway or wire Tramway, it was suggested to him by a well known citizen of San Francisco, that if he could solve the problem of cheap and rapid passenger transit over the steep streets of this city he would be doing a good thing for the property on the hills surrounding the city, and would enable the residents to enjoy greater sanitary advantages and more agreeable prospects.

Acting on this suggestion Mr. Hallidie devoted himself closely to the consideration of the subject, and after careful thought and experiment, matured a system of street railroading by which the cars are hauled up the steepest streets and most changeable grades by a constant traveling rope concealed in a tube under ground. The surface of the street presenting the same appearance, and no more obstruction than any other street in the city having a railroad on it, and in no way interfering with the ordinary traffic or business on the streets.

This system, for which he has obtained numerous patents, was adopted by the Clay Street Hill Railroad Company, August, 1873, by the Sutter Street Railroad Company, February, 1877, and the California Street Railroad Company, April, 1878.

All these roads have been constantly running since the above dates, and have demomstrated to the most skeptical the superiority and economy of this system, over any other for city traffic.

Although the inaccessibility of the hills, and the consequent steepness of the streets was the immediate cause of this invention, yet its applicability is not confined to heavy grades, nor is its great economy as compared to horse railroads so clearly demomstrated as it would

be on a comparatively level road, where it can work in fair and direct competition with the present system of horse railroads.

Nor does the City of San Francisco give any oppotunity for a practical illustration of the usefulness of this system during cold winter days, and heavy falls of snow, both of which are absent in the mild winters of this city where the thermometer rarely reaches the freezing point, and snow is never seen.

The difficulties in keeping a line of street railroad open during the winter in many of the northern cities, are almost innumerable. The snow, and slush or ice, giving a poor footing to the horses employed in hauling the snow plows, scrapers and sweepers used in clearing the railroad tracks. By the endless rope system, these difficulties are largely overcome, as the rope furnishes a hauling power superior to any number of horses, and at nominal expense, and by means of which the tracks can be kept well cleared of snow and ice, while hot water pipes which run inside the tube through which the rope travels, prevents any freezing in its vicinity.

This system of street railroads is adapted to all kinds of city or town railroading, where the surface of the street has to be kept free from obstructions, where locomotives are not permitted, or where the grades are too heavy to permit the use of horses, locomotives, or Steam traction engines.

A description of the Clay street Hill Railroad will best explain its mode of working.

Clay Street is a central street in the City of San Francisco, and is closely built up by residences, it is but forty-nine feet wide from house to house, and between the sidewalk is occupied by two lines of gas pipes, one line of water pipe, a street sewer, and at the cross streets by water cisterns. ,

It is one of the oldest streets in the city, and the eastern terminus of the street railroad is at the old plaza where it intersects Kearny street. In the distance of 2791 feet west Clay street is crossed by six streets and reaches an elevation of 307 feet. Beyond in the distance of 1925 feet it is crossed by four streets and descends 160 feet, and for a further distance of 471 feet has an ascent of 15 feet to the west terminus of the railroad. The cross streets at their intersection with Clay street are level or rather a little curving, and vary in width from 45′ 5″ feet to 68′ 9″.

By referring to Fig. 1, showing Clay street in section, the contour of the hill will be seen.

The steepest grade is 1 in 6; and the entire length of the line is 5197 feet, occupying 12 minutes in transit.

The conditions to be used in building the road were that there should be no more impediment to ordinary traffic or business of the street than the usual street railroad; that the cars could be stopped as quickly on any part of the road, and should be under the perfect control of the conductor; that the cars should be easily and smoothly started; that it should be worked more economically than with horses; that no motor would be permitted that should frighten horses or endanger the lives of citizens, and that the cars should run regularly during the hours of 6 A. M. and 11:30 P. M., picking up and landing passengers at any street crossing.

The system determined on by Mr. Hallidie and adopted by him in the construction of the Clay Street Railroad met all these conditions, and the road was inaugurated on the 1st August, 1873, and has been in operation ever since, and without interruption up to this time, (June 1879.)

The engine and machinery are located at the top of the hill, See Fig. 1, and consists of a pair of 14x28 in. cylinders with a piston speed of 420 ft. per minute. From the engine the power is transmitted through a pinion and spur wheel to a grip pulley 8 ft. diameter, (for description see pages 37 and 38), which actuates an endless steel wire rope 1 inch diameter and 11,000 feet long.

The road has a double track of three and one-half feet gauge, and underneath the tracks and between the rails, there are tubes about two feet deep and eighteen inches wide, running the entire length of the road, and at intervals of about forty feet there are carrying pulleys in the tube (see fig. 6.,) and at the termini of the road, are horizontal pulleys of about eight feet diameter.

The Wire Rope is lead from the Engine Room by means of suitable pulleys into the tubes above refered to, passing through one tube around the horizontal pulley at the terminus, then through the other tube around the horizontal pulley at the other terminus, through the back into the Engine Room, and is supported on the carrying pulleys in the tube; these pullleys are twelve inches diameter except where there is a change of direction downwards, the pulleys at these points are four feet diameter, and at the change in the diameter of the rope upwards, there are depending pulleys of small diameter, the space at the crown of the tube being quite limited.

Along the entire length of each tube, at the top, and reaching to the surface of the street is an opening or slot, (See Fig. 6), sufficiently large

to allow the passage of a bar of iron or shank of a "grip", but not large enough to permit a carriage wheel to enter. This slot is not directly over the wire rope in the tube, but sufficiently on one side of it to permit the use of the upper or depending pulley for the purpose of depressing the rope at the change of direction upward, and to avoid the falling of water, dirt, etc. on the rope, as well as to permit the foot of the "grip" to pass by and under the upper pulley.

It will be understood now that when the engine is set in motion it causes the endless wire rope to travel in the tube between the upper and lower pulleys thereof, and that in order to utilize the traveling rope there must be a means of connecting it with the cars which run on the tracks on the surface of the streets. But it will be observed that in a street railroad where the grades are uniform or comparatively level, the upper or depending pulley is not required.

The connection between the cars on the street and the traveling rope in the tube is made by means of a "grip" which is described as follows:

Figure 4 is a skeleton view of the patent gripping attachment, and Fig. 5 is a perspective view. A vertical slide works in a shank, and is moved up and down by a screw and hand-wheel. The screw is shown in Fig. 4. The small upper sciew going down through the large hollow screw, operates it. At the lower end of this slide is a wedge-shaped block. The wedge actuates two jaws horizontally, which open and close according to the direction in which the slide is moved, closing when the slide is moved upward. These jaws have pieces of soft cast iron placed in them, which are easily removed when worn out. These pieces of iron are of proper shape and size inside to grip the rope when they are closed over it.

On both sides of these jaws and attached to them, are four small pulleys. These pulleys are held by means of rubber cushions, sufficiently in advance of the jaws to keep the rope off from the jaws, and at the same time to lead the rope fairly between them, allowing it to travel freely between the jaws, when they are separated, without touching them. When it is required to grip the rope, this slide is drawn up by means of the small screw and hand wheel before described, and the wedge, at the lower end closes the jaws over the rope, at the same time forcing back the small guide sheaves on to the rubber cushions. The shank, containing the slide, etc., is enclosed and retained in cast-iron slides, attached to the body of the dummy, Fig. 2, and a wrought iron standard, having a large nut at its upper end in which the large hollow screw

works as shown in Fig. 4. The "grip" is raised and lowered bodily through the opening in the tube from above the surface of the street to the rope in the tube by means of the hand wheel and nut working on the large hollow screw referred to. The "grip" is secured to a skeleton or traction car called a dummy, as shown in Fig. 2. The dummy is coupled to the passenger cars, at the bottom of the incline, and uncoupled at the top, and *vice versa*. At first the connection between the dummy and car was made by means of spiral springs, to prevent any jar in starting up, but this was found unnecessary. The arrangements made at the bottom of the incline for keeping the rope at the proper tension, and taking up the slack, prevent any noticeable jar in starting. As before stated, the rope is constantly in motion, running between sheaves placed in the tube. The slot of the tube is on one side of a vertical line drawn through the centre of the tube, and referring to Fig. 6, it will be seen that the foot of the gripping attachment projects on one side, giving it an L shape, enabling the jaws to pass under and over the rope sheaves in tube. In order to stop the car, the jaws of the gripping attachment are opened slightly; when they release the rope, the guide sheaves take it, and the car stops.

The shank, containing the slid which works in the slot of the tube, is one-half of an inch thick and 5½ inches wide, there being one-eighth play on each side; all the essential parts of the gripping attachment are made of steel.

Clay Street Hill Wire Rope Railroad.

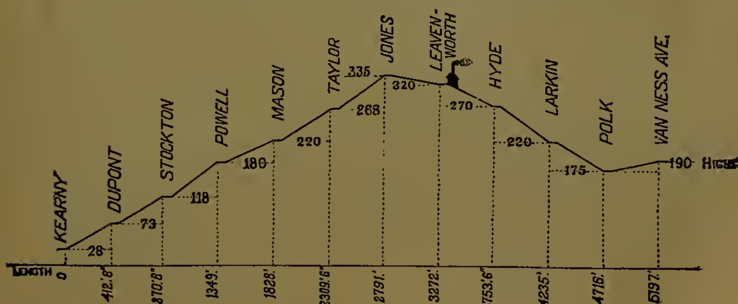


Fig. 1.—Section of Hill.

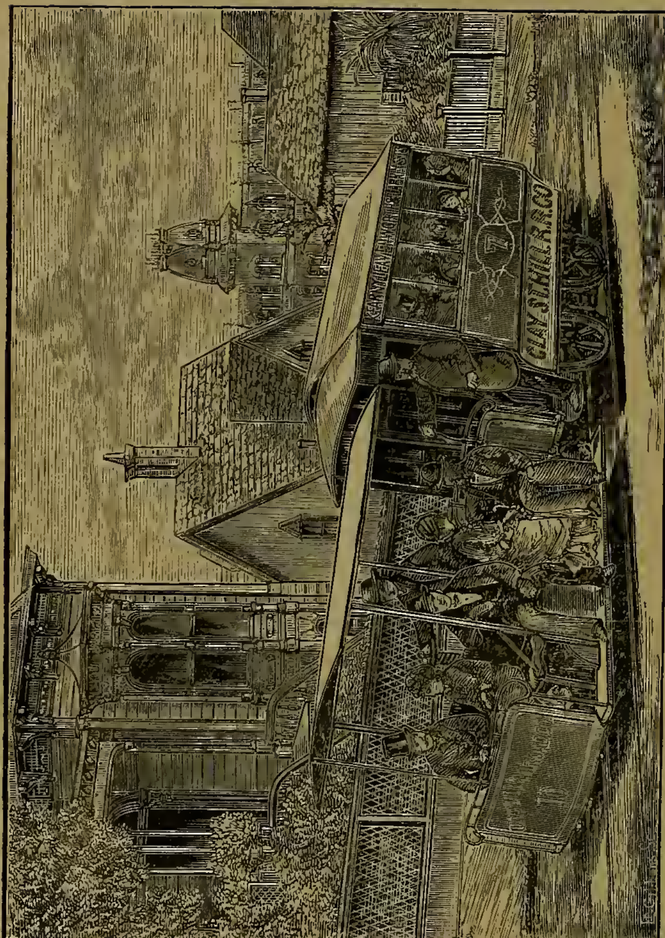


Figure 2.

Fig .3. Application of Power to Rope.

Fig 4. Skeleton View of Grip.

Fig. 5. Perspective View of Grip

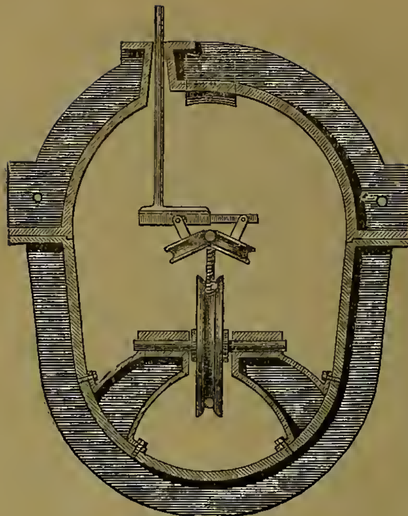


Fig. 6.

(There are other forms of grips, but all containing the same principle except so far as taking the rope up from above.)

The road has a gauge of three feet six inches. An ordinary thirty pound **T** rail is used, which is set flush with the street and presents a neat, smooth appearance. The rope runs at the rate of about five miles per hour, and the trip is made, including stoppages, in twelve minutes, the distance being 5,197 feet. The stretching arrangement at the lower end has a couterbalance of 3,300 pounds weight on a double purchase, which keeps a constant strain on the rope under all circumstances. At the termini of the road the car and dummy are transfered from one track to the other by means of a turn table, and as the available space at these points was very limited, and in view of this, some ingenuity had to be employed. When the traction car reaches the foot of incline, it is uncoupled from the car and run on to the turn-table, the slot in the turn-table allowing the shank of the grip to pass freely down. The table is then turned around one-quarter of its circumference, and the track and slots are then brought in the same line, The traction car is then run on the other table, which is turned back and the traction car is run on the up track. The car is then brought on the turn-table, transferred in the same manner and coupled

Fig. 7. A General view of the Road, looking down Clay Street towards the Bay of San Francisco.

to the traction car, ready for the ascent. Where turn-tables are used, this course is necessary, as there are double tracks; and the traveling wire rope runs down beneath one pair of and up under the other. As the gripping attachment passes down under the street through the slot, it is necessary to have a slot in both turn-tables to allow the traction car to be turned.

The original plan was to use switches, so that the dummy would be switched off, carrying the shank of the grip through a switch slot which connected the two tracks. This latter plan is the one adopted by both the Sutter Street and California Street Companies.

After nearly six years of working, this system has been pronounced by the best Engineers, to be the true solution of economical metropolitan rapid transit, where locomo'ives are not permited to run on the surface of the street.

Size of Gas Pipes.

Following is the London rule for gas pipe sizes: For 200 lights, two inch iron tube; 120 lights, one and one-half inch; seventy lights, one and one-fourth inch; fifty lights, one inch; twenty-five lights, three-fourths inch; twelve lights, one-half inch; six lights, three-eight inch; two lights, one-fourth inch.

Sound.

Sound has a mean velocity through air of 1,092½ feet per second, and passes through water at a speed of 4,708 feet per second.

Strength of Animals.

Two men working at a windlas with the cranks at right angles to each other, can raise seventy pounds more easily than one man can raise thirty pounds. The mean effective power of a man, unaided by machinery, working to best advantage, is raising seventy pounds one foot high in one second, for ten hours per day. The strength of a horse is equal to that of five men. A horse should be allowed four gallons of water per day. *One horse power in machinery* is estimated at 33,000 pounds, raised one foot high in one minute. A horse can exert this power for but six hours per day, therefore one horse power steam, equals four horses.

Mortars and Cements.

Stone Mortar, eight parts cement, three parts lime, thirty-one parts sand.

Brick Mortar; eight parts cement, three parts lime, twenty-seven parts sand.

Brown Mortar; one part lime, two parts sand, and a small quantity of hair.

Lime and sand, and cement and sand, lessen about one-eighth in volume when mixed together.

In mixing mortar the sand should be sharp and clean, and not mixed with the lime until it is slacked; the mortar should be mixed at least one week before using.

Cement for Coating Cisterns.—Mix glycerine and litharge until it becomes a thick paste, then apply; hardens quickly.

Rust Joint for Iron.—One pound sal ammonia, two pounds flour of sulphur, eighty pounds iron borings, made to a paste with water.

Cement for Cisterns or Water Casks.—Melted glue eight parts, linseed oil four parts, boiled into a varnish with litharge; hardens in forty-eight hours.

Alloys and Compositions.

Babbitt Metal, 3.7 copper, 89 tin, 7.3 antimony, equals 100 parts.

Brass, common, 84.3 copper, 5.2 zinc, 10.5 tin.

Brass, common, 75 copper, 25 zinc.

Brass, common hard, 79.3 copper, 6.4 zinc, 14.3 tin.

Brass Wire, 66 copper, 34 zinc.

Bronze, red, 87 copper, 13 zinc.

Bronze, yellow, 67.2 copper, 31.2 zinc, 1.6 tin.

Bronze Medals, 93 copper, 7 tin.

Muntz Metal, 60 copper, 40 zinc.

Pewter, 86 tin, 14 antimony.

Type and Stereotype, 69 lead, 15½ bismuth, 15½ antimony.

In the manufacture of alloys the most fusible metals should be melted first.

To make Babbitt's Metal: Melt four lbs. Copper; add by degrees, twelve lbs. Best Banca Tin, eight lbs. Regulus of Antimony, and twelve lbs. more Tin. After four or five lbs. Tin have been added, reduce

the heat to a dull red, then add the remainder of the metal as above. This composition is called *hardening* for *lining*; take one lb. of this hardening and melt two lbs. Banca Tin with it.

Melting Points of Alloys.

Lead 2, tin 3, bismuth 5	312°
Lead 1, tin 3, bismuth 5	210
Lead 1, tin 4, bismuth 5	240
Tin 1, bismuth 1	286
Tin 2, bismuth 1	336
Lead 2, tin 3	334
Tin 8, bismuth 1	392
Lead 2, tin 1 (solder)	475
Lead 1, tin 2 (soft solder)	360
Zinc 1, tin 1	399
Lead 1, tin 1	368
Lead 1, tin 1, bismuth 4, cadmium 1	155

75 parts of lead, 16 7-10ths parts of antimony, 8 3-10ths parts bismuth, forms a metallic alloy that expands in cooling.

In sandy soil, the greatest force of a pile-driver will not drive a pile over 15 feet.

A horse-power is equivalent to 33,000 lbs. raised 1 foot high in one minute.

Wire Fencing.

The most durable fence is a wire fence. The objection to a plain wire fence is, that the wire is too small to be seen by cattle; by running a board along the top this objection is removed. A wire fence made from single wires, is not so good as that made from a two or more wires twisted together.

Wire strand made from seven wires twisted together, make a very strong and durable fence, and if galvanized, will last for generations and will wear out probably fifty sets of ordinary fence posts.

We make wire strand of various sizes, and put it up on reels in one-half mile lengths, so that by putting it in a wagon it will pay off at the tail end, as the wagon is driven over the ground to be fenced in.